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ELEMENTS

OF

THE ART OF DYEING.

Printed by Walker & Greig,
Edinburgh.

ELEMENTS

OF THE

ART OF DYEING;

WITH A DESCRIPTION

OF THE

ART OF BLEACHING BY OXYMURIATIC ACID.

Second Edition.

By C. L. and A. B. BERTHOLLET.

TRANSLATED FROM THE FRENCH,

WITH NOTES AND ENGRAVINGS, ILLUSTRATIVE AND SUPPLEMENTARY,

By ANDREW URE, M.D. F.R.S.

PROFESSOR OF THE ANDERSONIAN INSTITUTION,

GLASGOW.

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ELEMENTS

OF

THE ART OF DYEING.

PART II.

OF THE PROCESSES OF ART.

SECTION I.

OF BLACK.

CHAPTER I.

Of the Processes for Dyeing Black.

VERY few substances are known which can afford of themselves a solid black; and they have been tried only on linen and cotton. The juice of the cashew nut, or *anacardium* of India, communicates a black colour, which resists, not only washing, but even boiling with soap and alkaline leys. It is used for marking linen. The *anacardium occidentale* affords also a durable dye, but it is merely brownish.

The *toxicodendron* yields a juice which produces nearly the same effect. The juice of the stems of hop affords a very durable brownish-red colour. Sloe juice gives a pale tint bordering on brown, which, washed several times with soap, and then moistened with solution of alkali, becomes of a deeper brown. On boiling sloes, their juice becomes red; and the red dye which it imparts to linen, changes, when washed with soap, into a bluish colour, which is permanent.*

According to Linnæus, † the juice of the berries of the *æctea spicata*, or *cristophoriana*, makes a black ink with alum; and the berries of the *impetrum procumbens*, or *erica baccifera nigra*, produce with alum a black colour bordering on purple.

A tree grows in the Brazils, which the botanists call *pomifera indica tinctoria*, or *genipa Americana*, whose berries and leaves dye a black-blue, which resists the action of soap.

The methods just mentioned of obtaining a black colour cannot be employed in dyeing, because the substances from which it is derived cannot be collected in sufficient quantities for the necessities of the art, and because the black which they afford is not comparable to that formed in the dyehouse. All black dyes are the result, therefore, of an artificial combination. The black molecules which are produced by the union of the astringent principle, or of another colouring

* Lewis' Exper. † Amœnit. Academ.

substance, and the oxide of iron, combine with the stuffs. We shall proceed to detail the principal processes by which this operation is performed on different kinds of goods.

According to the process which Hellot describes,* for dyeing woollen cloth black, it must receive the deepest blue or mazarine blue, be washed in the river on coming out of the vat, and then cleansed at the fulling-mill.

For 50 kilogrammes of cloth there are put into a boiler, of middle size, 8 kilogrammes of logwood, with as much Aleppo galls in powder, and the whole being enclosed in a bag, is boiled in a sufficient quantity of water for 12 hours. One-third of this bath is transferred into another boiler with one kilogramme of verdigris; and the stuff is passed through this solution, stirring it continually during two hours, taking care to keep the bath very hot without boiling. The stuff is then lifted out, another third of the bath is added to the boiler, along with four kilogrammes of sulphate of iron or green vitriol. The fire is to be lowered while the sulphate dissolves, and the bath is allowed to cool for half an hour, after which the stuff is introduced, and well moved about for an hour, after which it is taken out to air. Lastly, the remaining third of the bath is added to the other two, taking care to squeeze the bag well: 8 or 10 kilogrammes of sumach are thrown in; the whole is just brought to a boil, and then re-

* L'Art de la Teinture en Laine, &c.

freshed with a little cold water; one kilogramme more of sulphate of iron is added, after which the stuff is turned through for an hour. It is thereafter washed, aired, and put again into the bath, stirring it continually for an hour. After this, it is carried to the river, washed well, and then fulled. Whenever the water runs off clear, a bath is prepared with weld, which is made to boil for an instant; and after refreshing the bath, the stuff is turned in to soften it, and to render the black more fast. In this manner, a very beautiful black is obtained, without rendering the cloth too harsh.

Commonly more simple processes are employed. Thus the blue cloth is simply turned through a bath of gall-nuts, where it is boiled for two hours. It is next passed through a bath of logwood and sulphate of iron for two hours, without boiling, after which it is washed and fulled.

Hellot has found that the dyeing might be performed in the following manner:—For 18 metres (yards nearly) of dark blue cloth, a bath is made of 0.75 kilogrammes of fustic *(morus tinctoria)*, two kilogrammes of logwood, and five kilogrammes of sumach. After boiling the cloth in it for three hours, it is lifted out, five kilogrammes of sulphate of iron are thrown into the boiler, and the cloth is then passed through it during two hours. It is now aired, and put again in the bath for an hour. It is lastly washed and scoured. The black is less velvety than that of the preceding process. Experience convinced him, that the

maddering prescribed in the ancient regulations only gives a reddish cast to the black, which is obtained finer and more velvety without madder.

A black may be dyed likewise without having given a blue ground. This method is employed for cloths of little value. In this case they are *rooted*, that is to say, they receive a dun ground with walnut husks, or the root of the walnut tree, and are afterwards made black in the manner above described, or in some other way; for it is obvious, that a black may be obtained by several processes. (NOTE CC.)

According to Lewis, the proportions which the English dyers most generally adopt are, for 50 kilogrammes (about one cwt.) of woollen cloth previously dyed of a dark blue, about two and a half kilogrammes of sulphate of iron, as much gall-nuts, and 15 kilogrammes of logwood. They begin by galling the cloth, they then pass it through the decoction of logwood, to which the sulphate of iron has been added.

When the cloth is completely dyed, it is washed in the river, and passed through the fulling-mill till the water runs off clear and colourless. Some persons recommend, for fine cloths, to full them with soap water. This operation requires an expert workman, who can free the cloth thoroughly from the soap. Several recommend at its coming from the fulling to pass the cloth through a bath of weld, with the view of giving softness and solidity to the black. Lewis says, that passing the cloth through weld, after it has been treated with

soap, is absolutely useless, although it may be beneficial when this operation has been neglected.

We read in the Memoirs of Stockholm for the year 1753, that for nut-galls may be substituted the *uva ursi*, gathered in autumn, and dried with care so as to keep its leaves green. 50 kilogrammes of wool are to be boiled for two hours with eight kilogrammes of sulphate of iron, and as much tartar; the cloth is rinsed on the following day, as after aluming. 75 kilogrammes of *uva ursi* are then boiled in water for two hours. After removing it, a little madder is introduced, and the cloth is at the same time immersed in the decoction, in which it is left for an hour and a half, or an hour and three quarters, and thereafter rinsed in water. Lewis remarks, that this manner of dyeing gives a good enough black on blue cloth, but merely a dark brown on white cloth; and that the madder and tartar are of no use. The *uva ursi* throws down the iron in coarse black particles, which float through the water.

Different operations may be distinguished in dyeing silk black; the boiling of the silk, its galling, the preparation of the bath, the operation of dyeing, the softening of the black.

Silk, as we have seen, PART FIRST, naturally contains a substance called *gum*, which gives it the stiffness and elasticity peculiar to it in its native state; but this adds nothing to the strength of the silk, which is then styled *raw;* it rather renders it, indeed, more apt to wear out by the stiffness which it communicates; and although

raw silk more readily takes a black colour, yet the black is not so perfect in intensity, nor does it so well resist the reagents capable of dissolving the colouring particles, as silk which has been *(decreusée)* scoured or deprived of its gum.

To cleanse silk intended for black, it is usually boiled four or five hours with one-fifth of its weight of white soap, after which it is carefully beetled and washed.

For the galling, nut-galls equal to nearly three-fourths of the weight of the silk are boiled during three or four hours; but on account of the price of Aleppo galls, more or less of the white gall-nuts, or of even an inferior kind called *galon*, berry or apple galls, are used. The proportion commonly employed at Paris is, two parts of Aleppo galls to from eight to ten parts of *galon*. After the boiling, the galls are allowed to settle for about two hours. The silk is then plunged into the bath, and left in it from twelve to thirty-six hours, after which it is taken out and washed in the river.

Silk is capable of combining with quantities, more or less considerable, of the astringent principle; whence results a considerable increase of weight, not only from the weight of the astringent principle, but also from that of the colouring particles, which subsequently fix themselves in proportion to the quantity of the astringent principle which had entered into combination. Consequently, the processes are varied according to the degree of weight which it is wished to

communicate to the silk; a circumstance requiring some illustration.

The commerce of silk goods is carried on in two ways; they are sold either by the weight, or by the surface, that is, by measure. Thus, the trade of Tours was formerly distinguished from that of Lyons; the silks of the former being sold by weight, of the latter by measure. It was therefore their interest to surcharge the weight at Tours, and, on the contrary, to be sparing of the dyeing ingredients at Lyons; whence came the distinction of light-black and heavy-black. At present, both methods of dyeing are practised at Lyons, the two modes of sale having been adopted there.

Silk loses nearly a fourth of its weight by a thorough boiling, and it resumes, in the light black dye, one-half of this loss; but in the heavy black dye, it takes sometimes upwards of a fifth more than its primitive weight; a surcharge injurious to the beauty of the black, and the durability of the stuff. The surcharged kind is denominated English black, because it is pretended that it came to us from England. Since silk dyed with a great surcharge has not a beautiful black, it is usually destined for weft, and is covered (blended) with a warp dyed of a fine black.

The peculiarity of the process for obtaining the heavy black, consists in leaving the silk longer in the gall liquor, in repeating the galling, in passing the silk a greater number of times through

the dye, and even letting it lie in it for some time. The first galling is usually made with galls which have served for a preceding operation, and fresh gall-nuts are employed for the second. But these methods would not be sufficient for giving a great surcharge, such as is found in what is called the *English black.* To give it this weight, the silk is galled without being ungummed; and on coming out of the galls, it is rendered supple by being worked on the jack and pin *(chevillages).*

The silk-dyers keep a black vat, and its very complex composition varies in different dye-houses. These vats are commonly established for many years; and when their black dye is exhausted, it is renovated by what is called a *brevet.* When the deposite which has accumulated in it is too great, it is taken out, so that at the end of a certain time nothing remains of the several ingredients which composed the primitive bath, but which are not employed in the brevet. The description of a bath and *brevet* of this description may be seen in the work of Macquer.* There entered into it seeds of fœnugreek, of psyllium (fleawort), cummin, colocynth, the berries of buckthorn, agaric, nitre, muriate of ammonia, sal gem, litharge, lead ore, orpiment, corrosive muriate of mercury, &c. Macquer acknowledges that there are many useless ingredients in this process; and in fact several of

* Art de la Teinture en Soie.

them are no longer admitted. But the compositions not only of every country, but of every dyehouse, differ.

Iron filings are usually added to the dyeing bath; but some dyers, particularly at Tours, substitute for them the *moulée*, or the abraded dust of grindstones; this *moulée* probably acts merely by the particles of iron, which it contains in a very comminuted state.

While the silks are getting the preparatory treatment for dyeing, the bath is heated, taking care to stir it from time to time, in order that the *marc* (sludge or sediment) at the bottom may not become too hot. This bath should never be raised to ebullition. More or less gum and solution of iron are added, according to the different processes; and when it is judged that the gum is dissolved, and that the bath has arrived at a degree approaching to ebullition, it is allowed to settle for about an hour; the silks are then plunged into it, usually divided into three portions, that they may be immersed successively in the bath. Each portion is slightly wrung three times, and each time hung up to air. The object of this operation is to squeeze out the liquor with which the silk is impregnated, and which is exhausted, and to make fresh liquor penetrate it; but above all to expose the silk to the atmosphere, which deepens the black.

After each portion of the silk has experienced three wringings, the bath must be heated anew, putting into it again gum and sulphate of iron,

as at first. The operation performed in the interval from one heating to another, is called a *fire (un feu)*. Only two fires are given for a light black, but three for a heavy black; and the dyers let the silk remain in the bath, even after the last fire, for about twelve hours. 30 kilogrammes of silk are usually dyed in one operation, which is called a *heat (chaudée)*. If only the half of this quantity be dyed, there is occasion for no more than one fire for the light black.

The dyeing operation being finished, a little cold water is put into a tub, in which the silk is washed by turning or shaking it over the rods, (*on disbrode la soie en la lisant*).

The silk, on coming out of the bath, has a great deal of harshness. The operation by which it is freed from this, is termed the *softening*. Into a large vessel, nearly full of water, a solution of soap is poured, in the proportion of from two to two and a half kilogrammes of soap for every 50 of silk. The solution of soap is strained through a cloth into the water, and is well mixed with it. The silk is then introduced, and left for about a quarter of an hour, after which it is wrung out and dried.

For the dyeing of raw silk black, it is galled in the cold, with the bath of galls which have already served for the black of boiled silk. For this purpose, silk in its native yellow colour is made choice of. It should be remarked, that when it is desired to preserve a portion of the gum of the

silk, which is afterwards made flexible, the galling is given with the hot bath of gall-nuts in the ordinary manner. But here, where the whole gum of the silk, and its concomitant elasticity are to be preserved, the galling is made in the cold. If the infusion of galls be weak, the silk is left in it for several days.

Silk thus prepared and washed takes very easily the black dye, and the *disbrodure* (rinsing in a little water), to which sulphate of iron may be added, is sufficient to give it. This dye is made in the cold; but according to the greater or less strength of the rinsings *(disbrodure)*, it requires more or less time. Occasionally three or four days are necessary; after which it is washed, beetling it once or twice, and it is then dried without wringing, to avoid softening it.

Raw silk may be more quickly dyed, by shaking it round the rods in the cold bath after the galling, airing it, and repeating these manipulations several times; after which it is washed and dried, as above.

Macquer describes a more simple process for the black, with which velvet is dyed at Genoa, and he says that this process, rendered still simpler, has had complete success at Tours. The following is his description.

For 50 kilogrammes of silk, 10 kilogrammes of Aleppo galls, in powder, are boiled for an hour in a sufficient quantity of water. The bath is allowed to settle till the galls have fallen to the bottom of the boiler, from which they are with-

drawn; after which 15 kilogrammes of English vitriol (copperas) are introduced, with 6 kilogrammes of iron filings, and 10 kilogrammes of country gum, put into a kind of two-handled cullender, pierced every-where with holes. This kettle is suspended by two rods in the boiler, so as not to reach the bottom. The gum is left to dissolve for about an hour, stirring it from time to time. If after this time some gum remains in the kettle, it is a proof that the bath, which contains two hogsheads, has taken as much of it as is necessary. If, on the contrary, the whole gum is dissolved, from one to two kilogrammes more may be added. This cullender is left constantly suspended in the boiler, from which it is removed only when the dyeing is going on; and thereafter it is replaced. During all these operations the boiler must be kept hot, but without boiling. The galling of the silk is performed with one-third of Aleppo galls. The silk is left in it for six hours the first time; then for twelve hours. The rest, *secundum artem.*

Lewis states, that he has repeated this process in the small way; and that by adding sulphate of iron progressively, and repeating the immersions of the silk a great number of times, he eventually obtained a fine black.

The sulphate of iron, indeed, seems to be in too small proportion, in the process described by Macquer; and some inconveniencies must undoubtedly have been found in it, since its practice has not been retained at Tours. Lewis thinks

that the gum is of no use, and that it is all carried away in the washing of the silk; but if he had continued to dye in the same bath, he would probably have perceived that it served to maintain it. It appears, however, that an excess of it had been used in that process. It must assuredly be advantageous, when the quantity of gum is diminished, to add the sulphate of iron in portions, after each *fire*, (*chaque feu*). Lewis remarks, moreover, that although a good black may be dyed on white silk, without making use of logwood or verdigris, the addition of these two ingredients contributes greatly to improve the colour on silk as well as on wool.

The process of dyeing black on silk is very expensive, from the quantity of galls, as their price is much raised. It is of consequence, therefore, to try to lessen its quantity. We shall advert to a process extracted from the memoir of Anglès, which competed for a prize proposed by the academy of Lyons in 1776, in which this object was attempted.

The silk, boiled with care and washed in the river, is plunged into a strong decoction of green walnut peels, in which it is left till the colour of the bath be exhausted. It is then withdrawn to be slightly wrung on the pins, dried, and washed in the river. The decoction of the walnut husks is made by boiling for a full quarter of an hour; after which it is taken from the fire, and the froth is allowed to fall before plunging in the silk, which should have been previously soaked in

tepid water. The blue ground is given by means of logwood and verdigris, dissolving in cold water one part of verdigris for sixteen of silk. This is allowed to steep in it for two hours, and it is then passed into a strong decoction of logwood. It is gently wrung out and dried, previous to its being washed in the river. For a light black, the galling may be dispensed with; but for obtaining a heavy black, the silk must be galled with half its weight of gall-nuts.

To prepare the bath, one kilogramme of nut-galls, and one and a half kilogrammes of sumach, are macerated in 100 litres of water, over a slow fire, for twelve hours. Whenever the bath has become clear, one and a half kilogrammes of sulphate of iron, and as much gum arabic, are dissolved in it. The solution being made, the silk is plunged in at two successive times, and is allowed to remain each time for two hours, taking care after the first immersion to air and dry it before giving it the second fire; after which it is aired and dried equably. Two beetlings in the river are now given; after this it receives the third fire in the same manner as the two preceding, except that it is left four or even five hours in the bath. When it is drained and dried, two other beetlings are given in the river. Care must be had that during the operation the degree of heat do not exceed the middle term between freezing and boiling water, which corresponds to 40° R. (122° F.); and before giving the last two fires, one quarter

of a kilogramme of sulphate of iron, and as much gum arabic, must be added.

To remove the harshness that the black dye imparts to silk, Anglès prefers the decoction of weld to the solution of soap.

He says, that the blue of indigo given to silk before the black dye, allows it to take only a mealy black, but that with logwood and verdigris a velvety black is obtained. He also says, that green walnut peels soften silk. Although a fine black may be formed with walnut peels, and the bath which has been described, he adds to it, however, the logwood and verdigris, in order to save the necessity of employing much sulphate of iron, which attenuates (thins) the silk too much. Lastly, he thinks that nut-galls serve merely to give weight to the silk, and that sumach is sufficient for this dye.

Linen and cotton take with difficulty a sufficiently deep black, that will resist soap. Hence we are obliged to employ peculiar processes for dyeing them black; and hitherto few such dyes have been found to give satisfaction.

For dyeing cotton and linen black, a solution of iron is made use of, which is kept in a cask called the black cask, (*la tonne au noir.*) This solution is prepared either with vinegar or small beer, or with the washings of pressed grapes, which is soured with rye-meal or other ingredients, with the view of getting an acid liquor at the lowest price. Old iron is thrown into this liquor, and the solution is set aside to be used on

occasion, taking care not to employ it till six weeks or two months from its preparation. Astringents are often added to this bath, and particularly the decoction of alder bark, which, even alone, has the property of dissolving a considerable quantity of oxide of iron.

We remarked, in speaking of the acetate of iron, that this metal should be highly oxidized. It is consequently proper to separate the solution after it is made, from the metal below, which opposes its oxygenation.

Le Pileur d'Apligny describes the process* followed at Rouen, for linen and cotton yarns. They are first dyed sky-blue in the vat, then wrung out, and set to dry. They are galled in the proportion of one part of gall-nuts for four of yarn. They are left twenty-four hours in the gall liquor, then wrung out anew, and set to dry.

About ten litres of the black cask (*tonne au noir*), for every kilogramme of yarn, are then poured into a tub. In this, the yarn is turned on the sticks, and worked with the hand, in portions, for about a quarter of an hour; it is then wrung out and aired. This operation is twice repeated, adding each time a new dose of the black cask, which should be skimmed with care. The yarn is aired once more; it is then wrung out, and washed in the river to cleanse it well, and dried.

* L'Art de la Teinture des Fils et Etoffes de Coton.

To complete the dyeing of the yarn, a weight of alder bark, equal to that of the yarn, is boiled for an hour in a copper, along with a sufficient quantity of water. To this are added about one-half of the bath which has served for the galling, and sumach, equal to one-half the weight of the alder bark. The whole is made to boil anew for the space of two hours, after which this bath is passed through a searce. When it is cold, the yarn is turned through it on the sticks, and it is worked in it by portions at a time. It is aired occasionally, then it is let down into the bath, where it is left for twenty-four hours. It is now wrung out and dried.

In order to soften this yarn after it is dry, it is the practice to steep it, and work it in the residuum of a bath of weld, which has served for other colours, to which a little logwood is added. It is taken out and wrung, and immediately turned through a tub of warm water, into which one part of olive oil for sixteen of yarn has been poured. It is finally wrung out and dried.

Le Pileur d'Apligny describes a process in which he makes use also of madder, to give linen and cotton yarn a black colour, which he speaks of as very beautiful, and very durable.

The yarn is first of all scoured in the ordinary way, galled, alumed, then turned through a bath of weld. On coming out of this bath, it is dyed in a decoction of logwood, to which one-fourth part of sulphate of copper must be added for one part of yarn. On quitting this bath, it is washed

in the river, and wrung repeatedly, without twisting it too strongly. Lastly, it is dyed in a bath made with one part of madder for two of yarn. To render the black not liable to change, the yarn must be turned through a bath of boiling soap water.

Wilson describes the manner pursued at Manchester, as follows:* A galling is given with nut-galls or sumach, after which the dyeing is performed with the liquor of a bath composed of a solution of iron in a vegetable acid, formed not unusually with alder bark and iron; and then the goods are turned through the decoction of logwood with a little verdigris. The process is repeated till a deep black be obtained. It is necessary to wash and dry between each operation.

Mr Bancroft had announced, that the acid of tar was employed at Manchester for black dyes on cotton. Chaptal, in his dyes, used pyroligneous acid; but to Bosc we owe the details of the operation by which he himself obtained a fine black by means of that acid.†

"Fill a cast iron boiler with pyrolignous acid; add to it old iron, well oxidized, and boil. The solution of the oxide will take place rapidly. When the iron grows clean, and the solution black as ink, throw the whole into a cask to be

* An Essay on Light and Colours, and on what the colouring matters are that dye cotton and linen.

† Annales des Arts et Manufactures, tom. v.

employed at need. Prepare your cotton as usual, by giving it a blue ground. Gall, turn the hanks of cotton through a bath of solution of pyrolignite of iron, diluted with tepid water. Renew the gallings, and the turnings through the bath of pyrolignite of iron, till you have obtained a deep and brilliant black. Finish by passing your cotton through olive oil. This operation is simple. Throw on some tepid water a little olive oil; pass the cotton through this bath; it absorbs the oil; but it must be worked for a long time in the bath to diffuse the oil equally. This process softens, and gives suppleness to the cotton, as well as a great deal of brilliancy. Dry in the shade. The cottons are now of a perfect and very durable black. Every time that the bath of pyrolignite of iron has been employed, it must be thrown away as useless, and the old baths are never to be added to the cask."

Bosc intimates, that the stuffs dyed by means of pyrolignous acid, retain, with much tenacity, the odour of this acid, and that they must be exposed for some time to the air to rid them of it, before folding them up for packing.

The application of oil, which heightens the black, and imparts softness to the stuffs, is given to those which are woven, for example, to cotton velvet, by means of brushes, which are slightly imbued with it at their surface.

Hermstadt* recommends a process of Vogler, which consists in making use for a mordant of a

* Grundriss der Farbekunst.

solution of nitrate of lead, in turning the stuff through a solution of glue, and in dyeing it in a bath composed of gall-nuts, logwood, and sulphate of iron, for which last the acetate may be substituted.

CHAPTER II.

Observations on the Processes for Dyeing Black.

We have dwelt at sufficient length on the reciprocal action of astringents and the oxide of iron, and on the production of the molecules, which, attaching to stuffs, dye them black. But though the theory can lead to satisfactory explanations on this subject in general, it should advance with diffidence when it is to be applied to the processes of art. Circumstances unperceived, properties apparently slight, may influence the results sufficiently to cause in them some variations, for which no reason can be assigned, and to lead to the preference of practices which are empirical in so far as the trials in the small way differ enough by the rapidity of evaporation, the degree of heat, and the action of the air, to make us cautious of advising changes, whose success has not been verified by operations on the great scale.

We shall select, therefore, in the description of processes, those to which experience, or the name of their authors, appears to give authority; and we shall draw from theory, or even from our own

trials, such counsels as may guide well-informed artisans in the study and successive improvement of the processes which they employ.

Astringents differ from one another as to the quantity of the principle which enters into combination with the oxide of iron. Hence the proportion of the sulphate, or of any other salt of iron, and that of the astringents, should vary according to the astringents made use of, and according to their respective quantities. Gall-nut is the substance which contains most astringent; sumach, which seems second to it in this respect, throws down (decomposes), however, only half as much sulphate of iron.

The most suitable proportion of sulphate of iron, appears to be that which corresponds to the quantity of the astringent matter, so that the whole iron precipitable by the astringent may be thrown down, and the whole astringent may be taken up in combination with the iron. As it is not possible, however, to arrive at such precision, it is better that the sulphate of iron should predominate, because the astringent, when in excess, counteracts the precipitation of the black colouring particles, and has the property of even dissolving them.

This action of the astringent is such, that if a pattern of black cloth be boiled with gall-nuts, it is reducible to grey. An observation of Lewis may thence be explained. If cloth be turned several times through the colouring bath, after it has taken a good black colour, instead of ac-

quiring more body, it is weakened and becomes brownish. Too considerable a quantity of the ingredients produces the same effect; to which the sulphuric acid, set at liberty by the precipitation of the oxide of iron, contributes.

It is merely the highly oxidized sulphate which is decomposed by the astringent; whence it appears, that the sulphate will produce a different effect according to its state of oxidizement, and call for other proportions. It is right, therefore, to follow the advice of Proust, employing it in the oxidized state; but in this case it is only partially decomposed, and another part is brought, by the action of the astringent, into the slightly oxidized sulphate.

The molecules precipitated by the mixture of an astringent and sulphate of iron, have not at first a deep colour; but they pass to a black by contact of air, while they are moist.

In these phenomena may be found the reason of two methods which are adopted. 1. Black is not given by a single operation. The dyeing is interrupted and divided into different stages. Thus, the iron which has been disoxidized, can resume a sufficient quantity of oxygen for the succeeding stage, and the bath which could produce no more effect, acquires anew the property of affording black molecules. 2. The stuffs are aired during the repose of the dyeing; whence the hue of the molecules is deepened.

We stated in the theoretical part, that the black dye was only a very condensed colour, and that

it assumed more intensity from the mixture of different colours likewise deep. It is, for this reason, advantageous to unite several astringents, each combination of which produces a different shade. But blue appears the colour most conducive to this effect, and it corrects the tendency to dun which is remarked in the black produced on stuffs by the other astringents.

On this property is founded the practice of giving a blue ground to black cloths, which acquire more beauty and solidity the deeper the blue. Another advantage of this practice is, to diminish the quantity of sulphuric acid which is necessarily disengaged by the precipitation of the black molecules, and which would not only counteract their fixation, but would further weaken the stuff, and give it harshness.

For common stuffs, a portion of the effect of the blue ground is produced by the *rooting*.

The mixture of logwood with astringents contributes to the beauty of the black in a twofold way. It produces molecules of a hue different from what the astringents do, and particularly blue molecules, with the oxide of copper, commonly employed in the black dyes; which appears to be more useful, the more acetate the verdigris made use of contains.

The boil of weld, by which the dye of black cloth is frequently finished, may also contribute to its beauty, by the shade peculiar to its combination. It has, moreover, the advantage of giving softness to the stuffs.

The processes that are employed for wool, yield, according to the observation of Lewis, only a rusty black to silk; and cotton is hardly dyed by the processes proper for wool and silk. Let us endeavour to ascertain the conditions which these three varieties of dyeing demand.

Wool has a great tendency to combine with colouring substances; but its physical nature requires its combinations to be made in general at a high temperature. The combination of the black molecules may therefore be directly effected in a bath, in proportion as they form; and if the operation be prolonged by subdividing it, it is only with the view of changing the necessary oxidizement of the sulphate, and augmenting that of the colouring particles themselves.

Silk has little disposition to unite with the black molecules. It seems to be merely by the agency of the tannin, with which it is previously impregnated, that these molecules can fix themselves on it, especially after it has been scoured. For this reason, silk baths should be old, and have the colouring particles accumulated in them, but so feebly suspended as to yield to a weak affinity. Their precipitation is counteracted by the addition of gum, or other mucilaginous substances. The obstacle which might arise from the sulphuric acid set at liberty, is destroyed by iron filings, or other bases. Thus, baths of a very different composition, but with the essential condition of age, may be proper for this dye.

Cotton and linen have a great propensity to combine with the oxide of iron, so that they withdraw a portion of it even from its solutions in acids. If those processes be considered which are employed in calico printing, and which are capable of guiding us in dyeing cotton and linen, it is apparent that the application of the mordant is the first step, so that the cloth is, first of all, combined with the oxide of iron; after which it is turned through the dyeing bath.

When black, red, and violet are wished for at the same time, a bath of madder is employed, which affords all these three colours at once, according to the base which fixes the colouring molecules on the different portions of the cloth. The black thereby obtained is, in reality, merely a very deep but durable violet. This is the most ordinary process. If yellows or greys be wished for along with the black, sumach is made use of.

When cloths are to have only black and white colours, a decoction of logwood is employed, which affords a finer and less costly black, but one a little less durable.

We have ascertained, that by imitating these processes, adding a little acetate of copper, making a mixture of different astringents, and substituting the pyrolignous for the ordinary acid, blacks may readily be produced of a satisfactory beauty, whose vivacity is increased at the same time that the harshness derived from the dye is

diminished, by means of the oil with which the stuff is impregnated.

CHAPTER III.

Of Grey.

The shades of black are grey, from the brownest to the lightest. The greys may be made in two modes. 1. A decoction of pounded gall-nuts is prepared, and the sulphate of iron is separately dissolved. A bath is made corresponding to the quantity of stuff, which is to be dyed of the lightest shade; and when it is as hot as the hand can bear, the decoction of nut-galls, and the solution of sulphate, are poured into it. The wool or stuff is then turned through it. When it has come to the wished-for shade, it is withdrawn; and some decoction and solution are added to the same bath. A stuff is turned through this, to give it a deeper shade than the preceding. Thus the operation is continued to the brownest shades, always adding more of the two liquors. But it is better for the black-grey *(gris de maure)*, and the other deep shades, to give previously to the stuff a stronger or weaker blue ground.

The second mode of making grey, which Hellot found to be preferable to the one just described, because the decoction of galls takes better on stuffs, and because there is more certainty of employing only the proportion of sulphate of iron required for the shade, consists in boiling

for two hours the quantity of nut-galls judged proper, having bruised and enclosed them in a thin linen bag. The stuff is then boiled in this bath for an hour, *(en palliant)*, stirring it up well with the rake, after which it is lifted out. There must now be added to this same bath a little solution of sulphate of iron; and the stuff being turned through it, thus acquires the lightest shade. More solution of iron is to be progressively added, till the deepest hues be produced.

In both of these methods the brownest shades may be begun with, when there is no restraint from patterns, of which the precise hue is to be hit. In the latter process each piece of stuff is left in, for a longer or shorter time, till it take the wished-for shade.

It is not possible to fix beforehand the dose of the ingredients, the quantity of water, and the time necessary for each of these operations. The eye alone must judge of them. If the bath be strongly charged with colour, the wool need remain a shorter period; but if the bath begins to get exhausted, it will require more time. When the stuff is found to be not dark enough, it is returned a second, a third time, &c.; but if the colour be too deep, it becomes necessary to pass the stuff through a fresh tepid bath, into which a little decoction of galls had been put, or even through a bath of soap or alum. If thus, however, we go beyond the mark, it is requisite to re-brown the stuff. Reiterated operations are prejudicial to it; hence it is proper to attempt to

catch the desired shade at once, by withdrawing the cloth occasionally from the bath.

Care must be had that the bath do not boil, and that it be rather tepid than too hot. In whatever manner the greys are dyed, they should be immediately washed in a great body of water; and the brown-greys should be even scoured with soap.

It is frequently desired to mingle with grey the tint of another colour, as a reddish, agate, or hazel cast. In this case, after giving a greater or smaller tint of blue, according to the object proposed, the stuffs are turned through a spent cochineal bath, which has served either for scarlet or violet, adding to it gall-nuts, logwood, madder, &c. Thereafter a browning of greater or less depth is given with solution of iron. For hazel, old fustic and logwood are added to the galls, and the dyeing is given on a white ground. All the greys, except black-grey *(gris de maure)*, are applicable on silk without aluming. The bath is composed with fustet, logwood, archil, and sulphate of iron. These ingredients are varied according to the shade to be given. Thus more archil is employed for greys that are to have a reddish cast; more fustet for those which ought to incline to a russet or green; and lastly, more logwood for such as are to have a darker grey. For the iron-grey, logwood and solution of iron are had recourse to.

The black-grey requires aluming, after which the silks are taken to the river, and then receive

a bath of weld. A portion of this bath is thrown away to substitute for it the extract of logwood, *(jus de bois d'Inde)*. When the silk has been impregnated with this, solution of iron is added in sufficient quantity; and when the desired shade is hit, the silk is washed and wrung.

If the grey come out deeper than is desired, the silk is turned through a solution of tartar, and then through hot water; and if the colour be too much weakened, a fresh dye-bath is given it.

For linen and cotton, a blue ground is given to black-grey, iron-grey, and slate-grey, but not to the other greys. All the shades require a galling proportioned to the grey which is wished to be procured. Baths of nut-galls that had been previously used are often employed.

When the yarn has been galled, wrung, and dried, it is turned over the sticks in a bucket full of cold water, to which a suitable quantity of the *black cask (tonne au noir)*, and of decoction of logwood, is added. The yarns are worked in it in separate portions, then wrung out, washed, and dried.

Le Pileur d'Apligny gives two other processes for making grey, of which he pretends the dye to be more fixed.

1. The yarn is galled, turned through a very weak *black bath*, and afterwards maddered.

2. The yarn is turned through a very hot solution of tartar, slightly wrung, and dried. This yarn is then dyed in a decoction of logwood. The dye appears black; but on turning through

and working the yarn with attention in a hot solution of soap, the surplus of the dye is discharged, and there remains an agreeable and solid slate-grey.

A process, the success of which is known to us, consists in taking a very dilute solution of acetate of iron, (it is sufficient to add a little of this acetate to a quantity of water), and a decoction of sumach, also very dilute. The cotton is passed in succession from one liquor to the other, till the wished-for shade be attained. The finish is given by passing through a water slightly acidulated by sulphuric acid, otherwise the sumach gives a russet hue. By the same process may be obtained with nut-galls less lively greys; and the alder bark affords an agreeable one, which borders on hazel.

A skilful manufacturer of Rouen has communicated to us the following process, which he makes use of successfully for cotton velvets. A galling is given with an equal quantity of gall-nuts and logwood, after which a bath of cold water is administered, and next another bath of water, in which there has been dissolved a weight of sulphate of iron, equal to the one-half of the preceding ingredients. After working the cotton about a quarter of an hour in this bath, it is rinsed in cold water, and brightened.

For this purpose a bath of tepid water is used, to which one-eightieth of decoction of weld, and a little alum, are added. The cotton is left about

twenty minutes in this bath, after which it is washed in cold water, and dried.

By modifying the doses of the ingredients, greys from pearl-grey to the deepest grey may be thereby obtained.

For greys on printed goods, the same mordant is impressed as for a clear violet, and sumach or gall-nuts are employed according to the shade that is desired.

SECTION II.

OF BLUE.

CHAPTER I.

Of Indigo.

INDIGO is a blue colouring substance extracted from a plant, which is known under the names of *anil*, *indigofera*, and *indigo*.

The plant from which the indigo is obtained, or the *indigofera*, is cultivated in China, Japan, India, Madagascar, Egypt, and South America. There are several species of it; but in America, three are particularly distinguished. The *indigo franc*, or *indigofera tinctoria*, *Linn.*: it is the smallest, and produces the indigo of the lowest quality; but as it yields a larger quantity, it is often preferred. The second is the *indigofera disperma*, *Linn.*, the species cultivated in Guatimala. It is taller, and more woody than the preceding. It affords a better indigo. The third is the *indigofera argentea*, or bastard indigo, which is still more woody than the last. It furnishes the finest indigo, but in smaller quantities than the others.

It would appear that this plant absorbs more foreign matters the more herbaceous it is. These are afterwards blended with the colouring particles.

When the *indigofera* exhibits the first signs of maturity, it is cut, and carried into vats, where it undergoes a fermentation, to which it is naturally prone. When it is cut down in a state of complete maturity, it affords a finer colour, but in less quantity. If it be cut too late, more of the substance is then lost, and an indigo of worse quality is obtained.

Three vats are placed one over another, at different heights, near a reservoir of water. The first is termed the steeper *(trempoir)*. Into this, filled with water to a certain height, the plant is put. Here a very brisk kind of fermentation soon begins, and much froth is thrown up. The gas that is disengaged is partly inflammable.

When the indigo maker ascertains that the fermentation is sufficiently advanced, and that the colouring particles have a tendency to separate, he runs off the liquor into the second vat, which is named the beating-vat *(batterie)*, in which the liquor is subjected to a beating with instruments constructed on purpose. Le Blond, in some observations which he sent to the Academy of Sciences, says, that this operation is intended for dissipating the carbonic acid generated in the fermentation, which hinders the colouring particles from falling down. He states, that the beating is not sufficient to effect the precipitation of

all the colouring particles, and that in French Guyana a process has been tried, which, by causing a more copious precipitation, has revived the hopes of the planters, who had given up this kind of manufacture. It consists in mixing a certain quantity of lime water with the liquor, whereby its carbonic acid is absorbed; but he conceives that the due proportion must not be exceeded, because too much lime water is prejudicial. This method was not unknown. P. Labat makes mention of it. Struve also thought that lime water promoted the precipitation of the indigo, by seizing the carbonic acid which held it in solution.*

When it is inferred from the blue colour that the beating has been sufficient, the vat is allowed to settle for two hours, that the colouring particles may begin to separate from the liquor, which contains a yellow extractive matter. It is now passed into a third vat, called the *diablotin* (settling vat). Here the colouring particles are suffered to subside; and the supernatant liquid is run off, in succession, by two stopcocks placed one above the other; after which the colouring particles themselves, which have a semi-fluid consistence, are drawn off, by a third stopcock, into conical linen strainers. When they are reduced to the consistence of a paste, they are turned out into square boxes, in the open air, which are placed under shades to shelter them from the sun.

* Bibliot. Medico-Physique du Nord, tom. iii.

The indigo produced in these operations differs not only according to the quality of the plant which afforded it, but also according to the pains taken in the preparation. Its colouring part, however, seems to be an uniform substance. Hence the qualities that distinguish it depend particularly on the proportion of the foreign parts blended with it, and on the greater or less consistence which it has taken in drying.

There is a light variety, called *light indigo*, or *flower indigo (indigo flore)*, which comes from Guatimala, and is of a beautiful blue. It floats on water, whereas the other kinds fall to the bottom of this fluid. It is the finest and the most precious sort. There is another, known under the name of *coppery indigo (indigo cuivré)*, because its surface assumes the colour of copper when it is rubbed with a hard body. Lastly, there are much less pure kinds, as that from Carolina.

The blue molecules of indigo, however, independently of foreign substances, owe a part of their properties to the preparation itself.

When the leaf of indigo is bruised, its juice speedily assumes a blue colour in the air. If, after bruising it, the juice be extracted by infusion, on leaving this solution in the air it grows turbid, and a greenish-blue fecula falls down, which preserves this green shade, notwithstanding repeated lotions, and a long exposure to the atmosphere. In Egypt, where the arts have made little progress, the plant is merely bruised,

infused in hot water, which is then run off into a pit of argillaceous earth, in which it is agitated with beaters, to cause the precipitation of its fecula; but the indigo thus obtained is always greenish, and affords a bad colour. In this state it seems more disposed to dissolve by means of fermentation; for the dyers require only to mix raw sugar with it, in order to establish the vats which are used for dyeing. A French artisan extracted a fine indigo, by subjecting the plant to the same preparations as in other countries.

The three parts of the process employed, have each a different object. In the first, a fermentation is excited, in which the action of the atmospheric air does not intervene, since an inflammable gas is evolved. There probably results from it some change in the composition of the colouring particles themselves; but especially the separation or destruction of a yellowish substance, which gave to the indigo a greenish tint, and rendered it susceptible of suffering the chemical action of other substances. This species of fermentation passes into a destructive putrefaction, because the indigo, as we shall see, has a composition analogous to that of animal substances.

Hitherto the colouring particles have preserved their liquidity. In the second operation, the action of the air is brought into play, which, by combining with the colouring particles, deprives them of their solubility, and gives them the blue colour. The beating serves, at the same time, to dissipate the carbonic acid formed in the first

operation, whose action is an obstacle to the combination of the oxygen. The separation of this acid is promoted by the addition of the lime; but if a redundant quantity be introduced, the excess would act in the indigo, and counteract the free combination of the oxygen.

The third part of the process has for its objects—the deposition of the colouring part, become insoluble by combination with oxygen; its separation from foreign substances; and its desiccation, which gives it more or less hardness, whence its appearance varies.

Indigo is not only of very extensive use in dyeing, but its chemical properties are very remarkable. They explain, in a clear and positive manner, those processes of dyeing in which they are used; they point out interesting analogies with other phenomena. For these reasons, we shall present, at some detail, the observations of the chemists who established this theory. We owe it especially to Bergman.

In the experiments of this great chemist,* water dissolved, by means of ebullition, a ninth part of the weight of the indigo. The portion dissolved by the water appeared partly astringent, partly mucilaginous, and partly saponaceous. The solution of alum, and of sulphate of iron and copper, precipitated its astringent parts.

* Analyse et Examen Chimique de l'Indigo. Mem. des Savans Etrang. tom. ix. Opusc. tom. v.

Quatremere* also separated by means of water the parts which are soluble. He states their quantity to be more considerable, the worse the quality of the indigo; and that, after this operation, the residuum has acquired the qualities of the finest indigo. He therefore proposes to purify what is of inferior quality, by boiling it in a bag, and renewing the water till it ceases to acquire colour. This operation would undoubtedly be beneficial, since the indigo would thereby be deprived of the yellowish particles which may alter its colour. Yet there are probably differences in the nature of the colouring particles themselves, and in the insoluble earthy matters, which could not in fact injure the colour, but might change the proportions of the colouring particles.

The powder of indigo digested in alcohol, gave at first a yellow tincture, then red, and lastly brown. It lost, by this operation repeated several times, about one-seventeenth of its weight. Water separates from this tincture a brownish resinous matter.

Ether acts on indigo nearly like alcohol; but the oils, both fixed and volatile, have little action on it.

Bergman mixed one part of indigo, well pulverized, with eight parts of colourless sulphuric

* Analyse et Examen Chimique de l'Indigo, tel qu'il est dans le Commerce, pour l'usage de la Teinture. Mem. des Savans Etrang. tom. ix.

acid, of specific gravity 1.90. The glass bottle in which the mixture was made, was slightly corked. The acid speedily attacked the indigo, and excited a great heat. After a digestion of 24 hours, the indigo was dissolved; but the mixture was opaque and black. On adding water it cleared up, exhibiting successively all the shades of blue, according to the quantity of water. It requires, at least, 10 kilogrammes of water in a cylindrical glass vessel, of 0.19 metre diameter, to render the smallest drop of this solution imperceptible.

If sulphuric acid be diluted with water, it attacks only the earthy matter that is blended with the indigo, and some mucilaginous ingredients.

Several goblets in which a drop of this solution was mixed with liquids, which contained different substances, such as acids, alkalies, neutral salts, were exposed for some time to a temperature of 15° or 20° (R.?) In some the colour was preserved without alteration; in others it became green, and was destroyed more or less speedily. Bergman explains the changes which he observed, by the property which some substances possess of carrying off phlogiston, and others of giving it. They are happily explained by the affinities of oxygen, which some substances afford, carry off, or absorb from the atmosphere.

The fixed alkalies, saturated with carbonic acid, separate from the solution of indigo a very fine blue powder, which is very slowly deposited. Bergman distinguishes this blue powder by the

name of *precipitated indigo*. It is also obtained by pouring, drop by drop, the alcoholic solution into saturated solutions of alum, of sulphate of soda, or of some other salts which contain sulphuric acid; but the liquid remains always a little coloured.

Muriatic acid digested, or even boiled with indigo, takes up the earthy part, the iron, and a little extractive matter, which colours it yellowish-brown, but without attacking in any manner the blue colour. If indigo be precipitated from sulphuric acid in this case, muriatic acid dissolves very easily a certain quantity of it, and forms a deep blue liquid.

The other acids, as the tartaric, formic, acetic, and phosphoric, comport themselves with indigo like muriatic acid. They dissolve precipitated indigo very well. Sulphuric acid, when too much diluted with water for dissolving indigo, and nitric acid, also too weak for decomposing indigo, only dissolve the earthy portion and the extractive matter, which are foreign to the colouring substance.

Concentrated nitric acid attacks indigo with such violence as to inflame it. If it be weakened to a due degree, it acts with less vivacity. The colour of the indigo becomes ferruginous (ochrey). The residuum, after this operation, has the appearance of the earth of umber, and forms in weight only one-third of the indigo. The fixed alkali precipitates a little oxide of iron, mixed with barytes and calcareous earth, from the

nitric acid which has acted on the indigo; but if too much alkali be added, a portion of the precipitate is redissolved, rendering the colour of the liquor deeper than it was before.

Haussman, in a very interesting dissertation, describes a connected series of observations on the changes which nitric acid produces on indigo.* When the whole indigo seemed destroyed, there was found a coagulum, which, after being deprived of all the nitric acid by washing, formed a brown and viscous mass, which dissolved in alcohol, and was soluble in only a great quantity of water. It possessed considerable bitterness. The water which has served for the lotions, afforded by evaporation small crystals, which were probably oxalic acid.

Oxygenated muriatic acid has little action on indigo in substance. But this inaction depends only on its cohesion, for it easily destroys the colour, and changes the composition of indigo when in solution. If the liquid be evaporated after this destruction is effected, there is found a blackish substance analogous to what results from the decomposition by nitric acid.

The decomposition by nitric acid and by oxygenated muriatic acid is reciprocal, and the effects depend on the passage of the oxygen of one of these acids, into a more intimate combination with the hydrogen and carbon, especially with the hydrogen. A combination is formed in which the

* Journ. de Physique, 1788.

carbon predominates, but in proportions determined by circumstances.

Sulphuric acid is, therefore, the only one which dissolves indigo; but we shall see that it produces this effect only by means of a change of composition, which alters very little the colour of the indigo, but renders it soluble in the other acids and the alkalies.

Fixed alkali dissolves some substances distinct from the colouring part of indigo; but it attacks slightly the colouring particles themselves. Ammonia, or the caustic volatile alkali, acts nearly in the same manner. Precipitated indigo dissolves readily, and in the cold, in the alkalies, whether fixed or volatile, if they be pure or caustic. Their blue colour changes gradually to green, and is eventually destroyed. But if the alkalies be combined with carbonic acid, they do not produce this effect. Lime water has little action on indigo, but it dissolves what has been precipitated. It alters and finally destroys its colour, nearly like the caustic alkalies.

Indigo exposed to the action of fire in an open crucible, or under a muffle, smokes, swells up, reddens, and sometimes even takes fire, evolving a white flame. One hundred parts of indigo leave thirty-three or thirty-four parts of ashes.

These ashes do not afford fixed alkali, when they are lixiviated with distilled water. Muriatic acid dissolves the greater part of them with effervescence. The residuum, which is insoluble,

forms an eleventh part, and has the characters of siliceous earth.

The solution made in muriatic acid produces prussian blue, on mixing it with prussiate of potash; but the iron thereby separated is not to be confounded with that which enters only into the colouring particles.

Besides iron and siliceous earth, the ashes contain calcareous earth and barytes.

Indigo detonates strongly with nitre. It afforded by distillation carbonic acid, a liquor which contained a little volatile alkali, and an oil similar to the empyreumatic oil of tobacco, which dissolved very well in alcohol.

Bergman concludes from his analysis, that 100 parts of good indigo contain:—

Mucilaginous parts separable by water,	12
Resinous parts soluble in alcohol, .	6
Earthy parts soluble in acetic acid, which does not attack the iron here in the state of an oxide, ...	22
Oxide of iron dissolved by muriatic acid,	13
47 parts remain, which are colouring molecules almost pure, and which when distilled afforded—	
Carbonic acid, ...	2
Alkaline liquor, ...	8
Empyreumatic oil, ...	9
Charcoal, ...	23

The charcoal, when burned in the open air, yielded four parts of earth, of which about one-

half was oxide of iron, and the remainder a very subtile siliceous powder.

It results from this analysis, that pure indigo contains nearly the same elements as animal substances, and it is to be supposed that some phosphate will be discovered in the ashes; but what distinguishes it from animal bodies, is the large quantity of charcoal which must give to its composition a greater stability than ordinary animal substances possess. We have, however, already seen, that if its preparations have not been made with skill, it might experience the effects of putrefaction. It is thereby altered or destroyed. That whose fermentation is pushed too far becomes black; it is termed *burned indigo*. (NOTE DD.)

Bergman ascribes its colour to iron, comparing it to the prussiate of iron, and to the black molecules formed by the combination of an astringent with the oxide of iron. This comparison does not appear to us exact. The iron present in the colouring particles of indigo, constitutes seldom more than the thirtieth part of their weight. The modifications which they receive from the combination of oxygen, or its expulsion, which we shall presently examine, do not correspond to the effects of the oxidation of this metal. It seems therefore more proper to consider the colour of indigo as a result of the reciprocal action of all its elements, than as a property derived from one of them.

It has been seen that the alkalies and lime do not dissolve indigo; but in the processes made

use of, it becomes soluble in these substances, from which it is afterwards precipitated on the matters that are dyed. The solution of indigo in alkali or lime is greenish; it becomes blue at its surface, because the indigo is precipitated from it under its natural form. Bergman remarks, that this green colour is not produced by the alkalies, as happens with several other vegetable substances. For these blue parts which have become green, recover their colour whenever the alkali is saturated with an acid, which itself would give them a red colour. But the particles of the indigo must have undergone a change, so as to become soluble in the alkalies; and the acids have not the property of making them red. Our object is now to examine what change the particles of indigo suffer in order to be dissolved in the alkalies.

Bergman examines two processes, with the view of ascertaining the cause of the changes experienced by indigo. We shall enter into further details on these processes, when we come to examine them as dyeing operations. It is enough at present to indicate them. If sulphate of iron, dissolved in water, be mixed with its own weight of indigo, and double its weight of lime, the indigo is soon dissolved. But Bergman has observed, that if the sulphate of iron be kept boiling in a great deal of water for several hours, and if this water be reduced by evaporation to a proper quantity, the solution can no longer take place. If to a solution of pure or caustic fixed alkali, indigo and sulphuret of arsenic or orpiment be

added, the bath soon becomes green, and the solution of indigo is accomplished. If, for the sulphuret of arsenic, be substituted the proportion of arsenic which it contains, the bath will never be fit for dyeing, but, on adding to it the proper quantity of sulphur, symptoms of solution will soon be seen.

Bergman ascribed these effects to the phlogiston communicated to the indigo, in the first case, by the precipitate of iron; and in the second, by the sulphuret of arsenic, through the agency of which it has become soluble in the alkali and lime. Hence, when the precipitate of iron has been deprived of its phlogiston by a long ebullition, it ceases to be able to dissolve indigo.

For this hypothesis, which might enable us sufficiently to foresee the results, we have merely to substitute the explanation founded on the positive effects of oxygenation and disoxygenation.

When indigo has assumed a blue colour, it contains a certain proportion of oxygen, which renders it insoluble. It may be compared to a metal, which, at a certain degree of oxidation, becomes insoluble in the acids, and which resumes its insolubility by the action of substances which can diminish its oxidation. Indigo is rendered soluble by the substances which can deprive it of a variable quantity of this element. The recent precipitate of sulphate of iron attracts oxygen powerfully from the atmospheric air, as Priestley has shewn. It must exercise a similar action on indigo, and render it soluble. When

the alkali acts on the sulphuret of arsenic, it precipitates from it the arsenic which is in the metallic state, robbing it of a portion of its oxygen. In this case, it acts on oxygen like the precipitate of iron, and in the same way renders the indigo soluble; but the co-operation of the oxidable metal is required. Oxide of arsenic produces no effect.

The disoxygenation, however, would not alone suffice, nor would it give a great enough solubility in water. The action of a substance possessing the property of uniting with the disoxygenated indigo, and increasing its solubility, must be joined, in order to prepare it for dyeing. This is the function of the fixed alkalies and the lime, in the different processes employed. It results from this twofold action, that, on one hand, the indigo is disoxygenated, while, on the other, it enters into a liquid combination with the alkali or the lime.

That this double action is essential, is evident; because the sulphuret of potash, or of soda, does not effect the solution of indigo, although it strongly attracts the oxygen, in order to be converted into a sulphate. The incompetency of its action must be ascribed especially to the resistance offered by the cohesive force of the indigo.

Some experiments of Haussman serve to confirm this theory. He put a solution of indigo, made by means of alkali and orpiment, in contact with the gas extracted from nitre by distillation

with heat, which is oxygen gas with a small proportion of azote. The whole of the oxygen was absorbed, while the indigo separated, resuming its blue colour, and the insolubility belonging to it in this state. The metal was reduced to an oxide. The sulphur formed a sulphate with the alkali, and the excess of the alkali could not retain in solution the indigo restored to its natural condition.*

To Haussman we owe several other interesting observations.

The sulphuret of antimony determines the solution of indigo equally with the sulphuret of arsenic; but this solution cannot be employed like that of the sulphuret of arsenic, because the metal forms a red precipitate, which is probably a sulphuretted oxide of antimony. This oxide, mixed with the sulphur, does not produce solution. Iron, in the metallic state, put into a concentrated alkaline liquor, along with indigo ground in water, did not, any more than zinc, determine its solution. Their force of cohesion, undoubtedly, counteracts this effect, while antimony, in

* All the effects which we explain by the oxidation and the disoxygenation of the indigo, might be accounted for by supposing, that the indigo is rendered soluble by an excess of hydrogen, and that the means which restore it to its blue colour, carry off from it this hydrogen. But this second explanation requires the admission of decompositions of water by causes of small energy, and it is not supported by the analogy of the oxidations of the metals, sulphur, phosphorus, &c. Hence, the one we adopt appears to have at least much more probability.

the metallic state, was able to occasion the solution.

The precipitate of copper, far from contributing to the solution of indigo, produced a contrary effect. It caused its regeneration in solutions made by means of sulphuret of arsenic or of antimony, as well as in that occasioned by the precipitate of iron. The solution of copper in ammonia acted in the same way. Haussman says, that the dyers take advantage of this property of copper, to exhaust more speedily the blue vats, which, when they have served too long, or are naturally little loaded with indigo, would furnish only very weak shades; while deeper ones are obtained by passing the pieces, before dyeing them, through a water slightly impregnated with sulphate of copper, or other cupreous solution, acid or alkaline. But the dyers of whom he speaks are in a mistake. When a solution of copper is poured into a transparent solution of indigo, the latter becomes of a deep blue, and the regenerated indigo is precipitated. In like manner, cloth impregnated with a solution of copper, on being plunged into a vat, comes out of it instantly of a deep blue, but washing removes this completely. This is, therefore, a means of quickly exhausting the vats, to the detriment of what the stuffs could take from it; for the regenerated indigo contracts no union with them. We shall see, that advantage is taken of this property of copper, to reserve (protect) the parts of a stuff in an indigo bath.

The oxide of copper produces these effects by the facility with which it gives up its oxygen to indigo that has been deprived of it. The oxide of tin, which has a contrary disposition, ought to act differently.

Bancroft found that tin, slightly oxidized, when mixed with an alkaline solution of indigo, speedily effected a solution of the latter, thereby forming, as is said, a good vat.

Tin, oxidized with a strong heat, or by the detonation of nitre, not only did not effect the solution of indigo, but it even counteracted it, on being mixed with the sulphuret of arsenic or antimony, or the precipitate of iron, so that in this state it gave up a portion of its oxygen.

Tin, slightly oxidized, may be dissolved directly in potash, and this solution acts on indigo. It quickly produces a vat, in which cloths are dyed of a very intense blue.

In all the processes employed for establishing the solutions of indigo, called *vats*, which we shall describe, there is present, conformably to the theory, several substances, which by an action more or less slow, serve to carry off the oxygen, while the lime, fixed alkali, or even the ammonia, unite to the deoxidized indigo, and give it more solubility.

It appears that indigo passes by these means through different degrees of deoxidation, so that its solution assumes different shades. In the most advanced state its solution is colourless; with less

oxygenation it passes to a yellow, and finally to a greenish hue.

While indigo is in solution, the portion of it in contact with the air absorbs oxygen, which combines with the indigo, and regenerates it, saturating, at the same time, the substance which tended to seize it, so that the surface becomes blue. Thence the froth, green at first, and then blue, is called *fleurée*, which is formed in well constituted vats, when they are agitated.

Indigo, when in the liquid state, easily forms combinations. It then unites to stuffs, and abandons the alkalies, which have but a feeble action on it. Notwithstanding the more intimate combination which it thus forms, it attracts oxygen, when the stuff is exposed to the contact of air, so that from yellow or green it passes speedily to blue. The same effect is produced, if on coming out of the bath it be dipped in very weak oxygenated muriatic acid. It thereby appears, that if cloth cannot combine directly with indigo, it is only in consequence of the counteracting force of cohesion.

Some vats are prepared and used in the cold, others are employed hot. The same difference is remarked here, in reference to stuffs, as in the most part of other dyes. Wool combines with a great deal of indigo. Its combination is very durable, but it requires heat, which disposes it to be formed. Silk takes a deep blue with more difficulty. Cold vats are proper for cotton and linen.

When indigo is dissolved by sulphuric acid, it gives a lively colour to stuffs. We shall examine this process; but the colour is much less solid than that produced by the ordinary vats; and we have seen, by the experiments of Bergman, that the precipitate obtained from this solution is different in some of its properties from native indigo, and that it is soluble in the other acids, and in the alkalies. The indigo must therefore have suffered some alteration in its composition.

It would seem that the observations which have been made on sugar, and other vegetable and animal substances,* may be applied to the action of sulphuric acid on indigo, and that it determines the formation of a little water, by the intimate combination of a portion of the oxygen and the hydrogen, which enter into the composition of the indigo. Thus, we may explain the great heat which is produced without any sulphurous acid being formed, the state of concentration in which the sulphuric acid must be, and why other acids, although powerful and concentrated, cannot effect this solution.

This alteration is, in our opinion, capable of being formed in different degrees; and when the heat has been rightly tempered, we hardly find in it the properties described by Bergman, whose accuracy cannot be called in question.

If sulphuretted hydrogen water be poured into a solution of indigo, diluted with so much water

* Essai de Statique Chimique, tom. iv. p. 530.

that it has but a faint colour, this is soon seen to disappear, and a little oxygenated muriatic acid restores it.

A hydrosulphuret produces this effect with a much more concentrated solution. If cotton be immersed in the liquid, it comes out colourless, but soon becomes green, and then passes to blue. A deep colour may be given to it by this means. Here the indigo did not offer any obstacle by its cohesive force; and the sulphuretted hydrogen, which is condensed, acts powerfully upon it.

The observations made by Bergman, on the effects that different substances produce on solution of indigo in sulphuric acid, are all easily explained by the property which they may or may not have of seizing its oxygen.

CHAPTER II.

Of Pastel and Woad.

PASTEL is a plant of the cruciform family, whose distinctive character is derived from the form of its silique, which is flattened like the fruit of the ash, is edged with a thin membrane, and contains two oblong seeds. Two species of it are distinguished, of which there are varieties; the cultivated pastel, *isatis tinctoria, Linn.* and the pastel of Portugal, *isatis lusitanica, Linn.* which differs from the first in being smaller, and in having narrower leaves. The first species sends out stems a metre

high, (a yard), of the thickness of the finger, which are divided into a number of branches, loaded with many large leaves, which are lanceolate, furnished at their edges with small smooth indentations, and of a bluish-green colour. The flowers are yellow, disposed in panicles at the summits of the stems. The root is thick, woody, and penetrates deeply into the earth.

This plant requires a good black mould, light, and well improved. It is sown in spring, after a double tillage in autumn. Three or four crops are obtained in a year. The first when the stems begin to grow yellow, and the flowers are about to appear; the others at successive intervals of six weeks or more, according to the climate and heat of the season.

The plant is mown with a scythe, washed in the river, and dried in the sun. Its desiccation must be rapidly performed; as, if the season be unfavourable, or if it rains, the plant runs a risk of being spoiled. A single night is sometimes sufficient to turn it black.

The plant is thereafter carried to the mill to be ground and reduced into a paste. This is formed into heaps, which must be covered to protect them from the rain. After fifteen days the pastel mass is opened up and bruised, mixing the interior with the crust that has formed upon its surface. It is then formed into balls, which are carried into a place exposed to the wind and the sun, in order to expel the humidity which might cause them to putrefy. These balls, piled one over ano-

ther, become hot imperceptibly, and exhale an odour of ammonia, which is stronger in proportion as the quantity is larger, and the season more hot. The heat thus begun, is increased by a slight sprinkling of water, till the pastel be reduced to a fine powder. It is now in the state in which it is found in commerce.

Pastel is cultivated and prepared in several parts of France. That of the southern departments is most esteemed. The name of *vouëde* (woad), is given it, in the departments of the north. Woad differs from ordinary pastel, merely in requiring a larger quantity of it to produce a like effect, as Hellot has proved.

Pastel affords, without indigo, a blue colour which has no brilliancy, but is very durable. As it yields much less colouring matter than indigo, and as its colour is inferior in beauty, the discovery of indigo has considerably diminished the culture and sale of pastel.

Astruc relates, in his memoirs on the natural history of Languedoc, that having treated pastel in the small way as the anil is treated to obtain its indigo, he procured a powder which produced the same effects as indigo. Hellot thence concluded, that the deep green of several plants is owing to yellow and blue particles, and that, if by fermentation the yellow could be destroyed, the blue would remain. But Lewis says,* that

* The Chemical Works of Gaspar Neumann, by William Lewis.

having made different species of plants putrefy in water, he obtained no blue fecula. This mixture of blue and yellow molecules to form the green of plants, is a supposition void of foundation. But some plants of different species appear to contain likewise colouring molecules analogous to indigo; and the pulp of the fruit of the *genippa americana, Linn.* contains enough of it, according to Bancroft, for dyeing directly a deep blue,—a circumstance already mentioned.

Several attempts have been made in different places to extract an indigo from pastel. It appears that the product is too small for the colouring substance to enter into competition with ordinary indigo.

In some parts of Africa, they content themselves with giving the leaves of indigo a preparation similar to what pastel is subjected to; but for extracting the blue fecula of pastel, they imitate the preparation of indigo. We shall now give a description of the operations followed in a manufactory, according to the account of it published by Gren.* The fresh leaves of pastel are taken, which are washed, to separate the impurities and the earth, in a tub of an oblong form, nearly three-fourths full. To prevent the water from buoying them up, pieces of wood are fixed across. On these leaves enough of pure water is

* Crell; Neueste Entdeckungen. A translation of it is to be found in the Bibliothèque Médico-Physique du Nord, tom. iii.

poured to cover them entirely, and the vessel is set in a moderate heat. There is formed, according to the temperature of the atmosphere, in a longer or shorter time, a copious froth on the surface of the water, which indicates the commencement of the fermentation. The surface becomes wholly covered by degrees with a blue skin, which presents to the eye shades of copper colour. Whenever there is a certain quantity of this froth, the liquor, which is of a deep green tint, is drawn off into another oblong vat by a stopcock placed immediately above its bottom, or otherwise the water is ladled out to put it into the other vat. In both cases it is necessary to run the water through a cloth into the other vessel, in order to separate the impurities, or the fragments of leaves which might pass over. The leaves are washed with a little cold water, to detach the portions of coloured skin which may adhere to them; and this washing is mixed with what had been drawn off. When this is done, lime water is poured into the liquor of the fermented pastel, in the proportion of two or three pounds for every ten pounds of leaves, and the mixture is strongly agitated for some time, to facilitate the separation of the indigo, which falls down on repose. To ascertain if the agitation has been continued long enough, a portion of the clear yellowish liquor is put into a common bottle, on shaking which, it will be seen whether blue be still separated, and in this case the liquor must be agitated anew. When the whole of the

indigo is finally separated and deposited, the clear water is drawn off by a stopcock, placed at some distance above the bottom of the tub, or by means of a syphon, which ought to be done without loss of time. In order to facilitate the separation of the water, the tub may be inclined to the side of the stopcock, as soon as the stirring is over. The blue colour which remains is poured into conical filters of linen cloth, or into large filtering bags, *(chausses d'Hippocrate)*, Hippocrates's sleeves. But as, at the beginning, a little colour always passes over, it should be received in a vessel placed beneath, and returned into the filter till the water comes off clear. The indigo contained in the filters is edulcorated with a sufficient quantity of water, and dried in the shade, or by a gentle artificial heat, taking care to cover it up.

The indigo may be procured without the addition of the lime water, but much less abundantly. If a larger quantity of lime water be added, the amount of indigo is indeed greater, but it is of inferior quality; because the surplus of the calcareous earth unites to the indigo. The alkaline salts, likewise, facilitate this separation of the blue colour; but it is not advantageous to employ them, because they afterwards dissolve a portion of it. With the addition of an acid, no precipitate takes place.

A certain time must elapse before it is proper to draw off the water which has fermented with the pastel leaves. If it be run off too soon, but little indigo is obtained; if, on the contrary, the

leaves be left too long in infusion with the water, they enter easily into putrefaction, diffusing a fœtid and peculiar volatile odour. Thenceforth no more precipitate can be separated, and the water remains permanently green. The same thing happens with the water drawn off, if it be neglected; and, even when the indigo is already separated from the liquor, care should be taken that this do not putrefy, otherwise the indigo will be entirely, or at least partially spoiled.

We must not, however, be too hasty in turning the water into the vat in which it is to be agitated, on the first appearance of the skin of changing blue, *(peau bleue chatoyante)*, since it is at this moment that the water takes up most indigo.

When the degree of the atmospheric heat is considerable, the fermentation is very speedily established, and 15 or 18 hours may be sufficient. It is especially requisite, then, to be very attentive, not to let it run into total putrefaction. If the heat of the atmosphere be too low, neither much froth, nor blue pellicle, is to be perceived, but the liquor inclines gradually to putrefaction, without presenting any marked phenomena before its commencement.

The plants piled up, or their juices, enter more rapidly into fermentation, but they afford only a dirty blue.

The indigo extracted from the pastel must be dried in the shade, because the sun destroys its colour.

D'Ambourney, who seems to have had no knowledge of the preceding experiments, was also occupied with the means of forming indigo from pastel.* He succeeded by letting the fresh leaves of pastel ferment in a certain quantity of water; he took out the leaves, and poured solution of caustic alkali into the liquor, after which he filtered it. A fecula remained on the filter, which he compared to the indigo of Carolina. The fresh and ripe leaves of pastel afforded 1-70th of fecula. (NOTE EE.)

CHAPTER III.

Of Dyeing Blue with the Indigo and Pastel Vat.

DIFFERENT processes are employed for dyeing blue by means of indigo. We shall take a survey of these processes, without entering into the details, which are well known in the dyehouse, and which are to be found described with much care in the work of Hellot.

The preparation for dyeing blue is not made in boilers, as for the other colours, but in large wooden vessels, to which the name *vats* is given. The vats are let down into the ground, so as to rise above it only to a man's standing height. As it is important to maintain the heat of the vats, they are not put in the same place with the

* Supplement au Recueil des Procédés d'Expériences, &c.

boilers, for which a free circulation of air is needed, but in an adjoining apartment, constructed in a manner adapted to preserve the heat. The name of *guesdres* is given to this arrangement *(emplacement)*, and the workmen are called *guesdrons*, who should be skilled by long experience to prevent the accidents to which the vats are liable.

Blue may be dyed with pastel or woad. A durable blue would be made, but it would not be deep, and only a small quantity of colour would be obtained, as has been said in treating of these substances. But by mixing them with indigo, vats are formed, very rich in colour, which are almost the only ones in use for wool and woollen stuffs. They are distinguished by the name of pastel vats.

Hellot has not designated with precision the proportion of the substances which are employed in the pastel vat. We shall borrow from the memoir of Quatremere the description of a vat of this kind. It is, however, to be remarked, that the quantities vary, not only in the different dye-houses, but also according to the shades wished to be obtained.

For a vat which is nearly 2.6 metres in depth, and 1.6 metres in diameter, two bales of pastel are thrown into the bottom, weighing together 200 kilogrammes, (about 4 cwt.), but they are previously broken down.

Fifteen kilogrammes of weld are to be boiled in a copper for three hours, in a quantity of water sufficient to fill the vat. When this decoction is

made, 15 kilogrammes of madder are added to it, and a basket of bran. The mixture is boiled for half an hour longer, and then refreshed (cooled) with 20 buckets of water. The bath is left to settle; the weld is withdrawn; this bath is transferred into the vat; and this is finally *pallied* (stirred up with a rake) during the whole period of the transvasion, and even a quarter of an hour longer.

All these operations being over, the vat is covered up very warmly, and left six hours in this state, after which it is uncovered, and raked during half an hour. The same thing is repeated every three hours.

When blue veins are perceived on the surface of the vat, its *ground (pied)*, as it is called, is given; that is to say, nearly four kilogrammes of quicklime. Whenever this substance is introduced, new characters make their appearance. The colour of the vat becomes of a blacker and deeper blue, and its exhalations grow much more acrid.

Immediately after introducing the lime, or at the same time, the indigo is put into the vat, after having ground it in a mill with the smallest possible quantity of water. When it has been diluted into the consistence of a thick pap, it is drawn off through a stopcock placed at the lower part of the mill, and it is thrown, without any other preparation, into the vat. The quantity of indigo which must be put into a vat, is determined by the shade to which the cloth or wool is to be

brought. For a vat composed in the above proportions, from 5 to 15 kilogrammes of indigo may be employed without inconvenience.

When, on striking the vat with the rake, a beautiful blue froth called *fleurée* is obtained, nothing more is needed previous to dyeing, except to work with the rake twice in the space of six hours, so as to mingle the materials perfectly. It is sometimes necessary to add also a little lime.

The bath, when first poured on the pastel, was boiling hot; and care must be taken not to leave the vat exposed to the open air longer than is necessary for raking. As soon as that operation is finished, the opening is closed with a large wooden lid, on which thick coverings are spread; and every method is had recourse to for keeping up the heat of the vat without the intervention of fire. But notwithstanding these precautions, however favoured by the arrangement of the *guesdres*, the heat can be kept up for only a certain time. At the end of eight or ten days it is found to be much reduced, and would be entirely dissipated if the liquor were not heated again.

This operation consists in transferring the greater part of the vat bath into the boiler, under which a strong fire is kindled. When this bath has received a sufficient heat, it is turned back into the vat in the same manner, and again covered with care.

The pastel vat is liable chiefly to two accidents: the first occurs when it gets stiff or thrown back, *(roide ou rebutée)*, according to the language of

the *guesdrons (vat-men)*. This accident is perceived, when, on uncovering a vat which had already afforded fine blue shades, it is found to be black, without any appearance of blue veins, and without *fleurée (froth)*. If it be raked up, only a black colour, more or less deep, is remarked, and the odour of the bath, instead of having in it something sweetish, as when the vat is in good condition, affects the nose, on the contrary, in a very pungent manner. If dyeing be attempted in a vat exhibiting these characters, the stuff takes no colour, or only a dirty grey. These bad qualities depend on an excess of lime; and Quatremere states, that he has communicated them to a vat by surcharging it with lime.

The vat-men employ different means to restore a repelled vat. Some put tartar into it, others bran, urine, madder; and others content themselves with reheating it. According to Hellot, the best remedy is to put into it bran and madder at discretion; and if it be only a little too much dosed with lime, it is sufficient to let it rest five or six hours at farthest, putting into it only a certain quantity of bran, and three or four pounds of madder, which are diffused through the vat. If it be *rebutée* to the degree of affording blue only when it is cold, it must be allowed to recover without disturbing it, and sometimes be left whole days without being stirred with a rake. When it begins to make a tolerable pattern, the bath must be reheated, in which case the fermentation usually revives. It may be excited

with bran and madder, and even with a basket or two of fresh pastel.

Hecquet d'Orval and Ribacourt advise to rest satisfied without raking up, if the bath be but slightly *rebutée* (thrown back); but if the evil has made more progress, to put into it some pounds of bran enclosed in a bag, and to diffuse through it at the same time three or four pounds of tartar in powder. The bag, after five or six hours, begins to float and is withdrawn, and the rake is used. If the vat be not yet restored, the same operation is repeated.

Quatremere says, that he has re-established a vat which he had thrown back by a surcharge of lime; and that for this effect he contented himself with heating twice, and leaving it then in repose for two days, after which it afforded a well characterized *fleurée*. He left it again in repose for three days; and lastly, heating it for the third time, he found it to be restored.

The second accident to which the pastel vat is subject, is putrefaction. When this accident occurs, the veins and the *fleurée* disappear, its colour becomes russet (*rousse*), the paste which is at the bottom rises up, the smell becomes fetid.

Quatremere asserts, that if a pattern of a dark blue be plunged into a vat thus deteriorated, its colour becomes several shades lighter. Putrefaction takes place in a vat, because it has not been sufficiently furnished with lime. Whenever the marks of putrefaction appear, we must hasten to correct it, by adding lime and raking up. This

operation is reiterated till the vat be restored; but we must beware of passing to the opposite excess.

It appears, that a just distribution of lime is the object which demands most attention in the conduct of a pastel vat. It moderates the fermentation of the pastel, and of the other substances that serve to disoxygenate the indigo; for this effect, pushed too far, destroys the colouring particles. But too strong an action of the lime becomes too great an obstacle. It is therefore proper to wait till the excess of lime disappears, undoubtedly by the successive formation of carbonic acid, or the source of the fermentation must be increased, or a portion of the lime be saturated by a vegetable acid. Another use of the lime is to hold in solution the colouring particles of indigo and of the pastel, which are disoxygenated. Woad is employed as well as pastel, but it appears that the preliminary preparation which both are subjected to, is not essential. We have seen a skilful dyer of Rouen employ for his vat the plant of woad simply dried; and assert that he derived more advantage from it than from ordinary woad.

The vat is raked up two hours before dyeing; and to prevent the *marc* which settles at the bottom, and which is called paste, from producing inequalities in the colour, there is introduced into the vat a species of trellis (lattice work), formed of thick ropes, which is called *champagne;* and when wool is to be dyed in the fleece, there is even placed over the lattice a net with close

meshes. The wools or stuffs are to be well moistened in clear water somewhat hot; they are to be squeezed and then plunged into the vat, where they are moved about longer or shorter, according as a colour of greater or less depth is wanted, airing them from time to time. The green colour which the bath communicates, changes into blue by the action of the air. It is difficult to give an equable light blue tone in a rich bath. The best method of obtaining these shades, is to use vats which are already exhausted and beginning to cool.

Wools and stuffs dyed blue ought to be washed with much care, to carry off the particles that are not fixed on the wool; and even the stuffs which are of a somewhat deep blue ought to be cleansed carefully at the fulling-mill, with a little soap, which does not affect the colour. Those intended to be dyed black must be treated in the same way; but this operation is less necessary for such as are to be turned green.

The name of *indigo vat (cuve d'Inde)*, is given to the vat into which no pastel or woad enters. The vessel which serves for this operation* is a boiler, which, by its conical form, leaves between it and the masonry which surrounds it, and on which its brim rests, a sufficient vacuity for introducing a fire. Into this copper are poured 40 gallons of water, more or less, according to its

* Mémoire sur l'Indigo, par Hecquet d'Orval et Ribacourt.

capacity. In this are dissolved three kilogrammes (about six pounds) of *cendres gravelées* (alkaline ashes of the vine), as much bran, and 0.368 of madder, which are all made to boil. Into the vats, even the *marcs* (sediments) of these materials are put. There is now poured in 3 kilogrammes of indigo ground with water. Careful raking follows. The vat is shut up; a slow fire is placed round it; a second raking is given 12 hours after it is mounted, and thus in succession, from 12 hours to 12 hours, till it has come to blue, which will take place at the end of 48 hours. If well managed, the bath will be of a fine green, covered with coppery flakes and scum, or blue *fleurée*.

This vat is much easier to conduct than that of pastel; but as its whole blue is derived from indigo, it is dearer. The alkali which serves as solvent being more soluble than lime, the dyeing bath is much richer in colour; lastly, the cloths retain more softness in it than in the pastel vat, where lime is the solvent. When the above vat is in the suitable state, it is employed for dyeing in the manner which has been indicated for the pastel one.

Hellot describes two vats in which indigo is dissolved by means of urine. Madder is added, and to one, vinegar, and to the other tartar and alum, each equal in weight to the indigo. The quantity of urine should be considerable. The solution of indigo, deprived of its oxygen by urine and madder in fermentation, is due to the ammonia formed in the urine, either by the action

of heat or fermentation. Hellot remarks, that an effervescence occurs when the solution of alum and tartar are poured in, substances which serve probably to hinder the progress of putrefaction. But these vats are not comparable to the vat of pastel and the vat of indigo, by means of which much more work is dispatched; they can only answer in small dyehouses.

For dyeing silk blue, the indigo vat above described is employed. More indigo is usually put in than the dose which has been indicated; but the proportions of bran and madder are nearly the same. Macquer states,* that if a weight of madder equal to one-fourth of the *cendres gravelées* be introduced, the vat becomes green, and its colour is surer on silk, without having a less agreeable cast. The pastel vat and the others spoken of, are not fit for dyeing silk, because they do not colour with sufficient promptitude.

When the vat is in working condition (*en etat*) there is given it, what is called a *brevet*, with about a kilogramme of *cendres gravelées*, and an eighth of madder. It is raked up; and after four hours it may serve for dyeing. The heat should be then sufficiently reduced, so that the hand may be held in it without pain.

The silk, previously boiled with soap in the proportion of 30 per cent of its weight, and then well cleared of its soap by two beetlings, or even more, in running water, is plunged into the vat,

* Art de la Teinture en Soie.

As it is very liable to take the colour unevenly, it must be dyed in small portions. The workman, therefore, immerses the hanks (*matteaux*) one after another, passing them round a cylinder of wood; and when he has turned them several times in the bath, he wrings them forcibly over the bath, and airs them to make the green become blue (*déverdir*). When they appear perfectly ungreened, he throws them into pure water, and then wrings them several times with the *espart*, (pin).

We must take care that the silk just dyed should be very speedily dried. During winter and damp weather, it is dried in a chamber heated by a stove, exposing it on a kind of frame which is kept in constant agitation.

When the bath grows weak, and its green colour diminishes, a *brevet* is given it, into which there enter half a kilogramme of *cendres gravelées*, a little madder, and a handful of well washed bran. When the indigo is found to be exhausted, more of it must also be restored to the bath, along with the due proportions of *cendre gravelée*, madder, and bran.

Some dyers turn to advantage the weakened vats for dyeing light shades; but the blue obtained in this case is less beautiful and less permanent, than if for these shades fresh vats were used, into which a smaller quantity of indigo entered.

Indigo alone cannot give a deep blue to silk. For this purpose it is necessary to prepare it, by giving it another colour or ground (*pied*). For

turkey-blue (*le bleu turc*), which is the deepest, a very strong bath of archil is first given, and one a little weaker for king's blue (*bleu de roi*). It is then turned through a fresh and well furnished vat. The other blues are made without any ground.

A blue as deep as king's blue is also made, for the ground of which cochineal is used instead of archil, with the view of giving it more solidity, which occasions it to be called *fine blue*.

By means of verdigris and logwood, a blue which possesses very little solidity is given to silk. But its durability may be much increased, by giving it first of all, by this means, a lighter shade than what is wished for, next passing it through the archil bath, and finally through the vat.

To dye raw silks blue, such must be chosen as are naturally white; they must be well soaked in water, and then turned through the vats in separate hanks, like the scoured silks. Raw silks take the dye generally with more facility and activity than those which have been boiled. The boiled should, if possible, be passed through the vat before the raw. If raw silk require archil, or the other ingredients above mentioned, it is to be treated like the boiled silks.

According to Le Pileur d'Apligny, the vat for dyeing linen and cotton is a cask capable of holding nearly 500 litres. The quantity of indigo employed is usually from 3 to 4 kilogrammes. This indigo, after being ground, is boiled in a ley, run off clear from double its weight of pot-

ash, and lime equal to the weight of the indigo. The boiling is continued till the indigo is well penetrated with the ley, stirring this mixture with care, and taking pains to prevent the indigo from sticking to the bottom, and burning.

During the boiling of the indigo, an equal weight of quicklime is to be slaked; to this about 20 litres of hot water are added, and sulphate of iron is dissolved in it to the amount of double the lime. When the solution is finished, the liquor is poured into the vat, which should be previously half filled, or nearly so, with water. There is afterwards poured over it the solution of the indigo, and the remainder of the ley, which had not been employed in the boiling, is added. When the whole has been poured into the vat, it must be filled up with water, to within two or three finger-breadths of the edge. It is stirred with the rake two or three times a-day, till it be in a condition for dyeing, which takes place at the end of 48 hours, often sooner, according to the warmth of the air, which accelerates, more or less, the formation of this vat.

Some persons add to a vat, composed nearly like the preceding, a little bran, madder, and pastel.*

At Rouen another process is followed, which Quatremere has described. The vats are constructed of a species of gun flint; the inside

* Procès-verbal des Operations de Teint faites à Yvetot par François Gonin.

and outside are covered with a kind of coating, made with a fine cement. A certain number of these are placed in one dyehouse, arranged in one or in several parallel lines.

A vat may contain four hogsheads of water, and there may be put into it from nine to ten kilogrammes of indigo, previously macerated, during eight days, in a caustic ley, strong enough to float an egg. This indigo is then ground in a mill, in which, indeed, the maceration frequently takes place. The vat is then filled, with the exception of a small space, and ten kilogrammes of lime are introduced into it. When it is well slaked, the vat is raked, and 18 kilogrammes of sulphate of iron are put in. Whenever the solution is completed, the mill-ground indigo is poured in through a sieve. The vat is raked seven or eight times the same day; and, after a repose of 36 hours, it may be used for dyeing.

There must be vats established at different periods. They begin by passing the cotton or yarn through the most exhausted vat, and they continue thereafter to proceed from vat to vat till they come to the strongest, unless before reaching it the wished-for hue is obtained. The cotton or yarn must be wetted before entering the first vat. It should not be left more than five or six minutes in the bath, because it takes up in this time nearly the whole blue with which it can charge itself.

When the dyeing in one vat is over, it must be raked up, and no longer worked upon, till it settle

at least 24 hours. If it is recently set, however, it does not need to stand so long.

When a vat has been dyed with, three or four times, it begins to be altered. When raked, no more blue veins are perceived at its surface, where it becomes black. In this case, it must be replenished *(renourrie)*, for which purpose, two kilogrammes of sulphate of iron, and one of quicklime, are added, and it is twice raked. The vat may be replenished three or four times, diminishing its ingredients in proportion as it declines in strength and quality.

In the vats just mentioned, it is the potash and lime which give solubility to the indigo disoxidized by the action of the precipitated iron. It may be thence inferred, that the sulphate of iron employed should be little oxidized, for in a state of high oxidation it produces no effect.

Lime may be used alone for precipitating the sulphate of iron, and dissolving the indigo. In this case, the solution of indigo is less concentrated, and we cannot succeed, or at least we cannot succeed so quickly, in giving to cotton or thread *(fil)* so intense a blue by means of that vat, as by the preceding. But this circumstance is even frequently of advantage. Some persons increase the concentration of this vat, by adding to it a little orpiment and potash.

Bergman and Haussman have given particular descriptions of this vat, with proportions a little different. The latter remarks on this occasion, that the sulphate of iron must not contain copper,

for the oxide of copper restores the indigo, which it is our interest to keep in a state of deoxidation till it be combined with the stuff. This observation is applicable to all the cases in which sulphate of iron is used along with indigo. He further remarks, that cotton cloth passed through water acidulated with sulphuric acid, on its quitting this vat, assumes a finer blue than if it be merely washed in the river, or set to dry.

We shall now point out a vat of this kind, the good constitution of which is confirmed by experience; as also the different uses that may be made of it.

The proportions employed for this vat are one part of indigo, two of sulphate of iron, and two of lime. After raking it for several hours in succession, when we set it, it is allowed to settle two days; we then dye with it.

Before dyeing, the froth *(fleurée)* is removed; and every evening, after the day's work is over, the replenishment is given to the vat, by putting into it some liquor *(bouillon)* from a little vat prepared for this purpose, with a much smaller proportion of water than there is in the dyeing vat, to which the froth of the latter is added. It is raked, covered up, and left at rest till the work be resumed. When the vat is weakened, a little power is communicated to it by the addition of some lime, and sulphate of iron.

For the dyeing of cloths, they must be stretched upon frames, fixing their selvages to little hooks (pins) with which the cross-bars of the

frames are provided. By means of a rope, running over a pulley, the frame is dipped into the vat. A slight agitation is given to it for a little while, to moisten the cloth more equably; the frame being so suspended that the whole breadth of the piece may be in the vat, without allowing the bottom of the frame to touch the sediment. After letting it become blue (in the air), it is washed with care, especially if *preserves* (resist pastes) be printed upon it. In order to dye two blues along with white (spots), the reserve is impressed, which should cover the white and the pale blue. It is dyed, washed, and the reserve is a second time applied to the places which are to remain white: such as have been reserved at the first dyeing, not being so at the second, take a lighter hue than the ground of the cloth. When the reserved places are to be dyed after the blue dye, the mordant is mixed with the reserve.

The property which the oxide of copper possesses of giving up its oxygen to indigo, and thereby depriving it of its power of fixing on stuffs, is made use of for reserves.

The reserves are usually composed of verdigris, pipe-clay, and several substances, which vary in different receipts. The verdigris is the only active one: the pipe-clay kept in suspension by the mucilage, which serves to thicken the reserves, may have the advantage of lessening the quantity of mucilage necessary for the thickening, and rendering the reserve more easy of application. To the verdigris, sulphate of copper is usually

joined, and sulphuric acid is added, undoubtedly with the view of rendering this salt more soluble. The composition of a good reserve resolves itself into the employment of the most soluble solution of copper; 1. For applying more oxide to the stuff; and 2. That its crystallization may not make it difficult to print on. For very deep blues, however, which require a long continuance of the cloths in the vat, some substance must be added to the reserve that may prevent it from dissolving in the vats. With this view, tallow or wax is intermixed, while the reserve is heating so as to thicken it. The compositions formerly used for reserves, owed much of their effect to the wax. It was kept in solution (fusion?) in order to be applied on the cloth, where it formed a kind of varnish that was removed by hot water after the dyeing.

If it be wished to give cloth blue figures on a white ground, a style of work called *delft-ware blue*, or *English blue*, this process is divided into different stages. The ground indigo, mixed with sulphate of iron, is printed on the cloth, which is stretched on a frame similar to that above described, and passed through a vat containing lime. Here it remains for some time. It is then plunged into a vat which contains a solution of sulphate of iron, marking from 3½° to 4° of the areometer of Baumé, (1.025 sp. gravity). It is now returned into the quicklime vat, passing thus alternately four times from one of these vats to the other. When it quits for the fourth time the

vat of sulphate of iron, it is plunged into a vat containing a feeble alkaline solution, in which it remains an hour, and lastly, into a fourth vat holding sulphuric acid diluted with water.

What occurs in a vat, takes place here on those parts of the cloth to which the indigo and sulphate of iron had been applied. The sulphuric acid dissolves away the oxide of iron with which the cloth is covered. To remove it completely, the cloth must be turned through this acid kept hot in a leaden boiler.

To have patterns in delft-ware blue, bearing different shades, it is sufficient to put into the colour printed on, different quantities of indigo.

Bergman describes another vat, very convenient and expeditious, for thread (yarn) and cotton, which is described also by Scheffer.* A very strong solution of alkali is taken; 12 grammes of well-ground indigo are added to it for every litre of liquid. After some minutes, when the indigo is thoroughly penetrated with it, 24 grammes of powdered orpiment are put into the liquor. The bath must be well raked, when, in a few minutes, it becomes green, forms a blue froth, and shews a pellicle. The fire should now be extinguished, and the dyeing may be commenced.

This vat does not differ from the preparation applied to cotton cloths, which is called pencilling blue *(bleu d'application)*, except in the proportions of orpiment, and especially of indigo,

* Essai sur l'Art de la Teinture.

which are much larger than in the latter. For this preparation there is employed, according to Haussman, for 100 kilogrammes of water, 15 of potash, 6 of quicklime, as much orpiment, and 8 kilogrammes of indigo. Oberkampf, the whole of whose processes have been improved with so much care, employs a still greater proportion of indigo. In the process of Bergman, the indigo constitutes nearly the 24th part of the water; still less in that of Scheffer; 1-12th in that of Haussman; and 1-9th in that of Oberkampf. The proportions of the other ingredients vary in these different processes. It would seem, that these preparations may succeed within a scale very extensive as to the proportions; nor would it be easy to determine what are the most advantageous ones for the object proposed.

Three processes are employed for giving blue in the art of calico-printing.

The first of these processes is used for dyeing cloth whose ground is to be blue or green; and whenever they bear colours which are to be kept from varying in the vat, these are covered with the white reserve.

If the cloth is to retain a white ground, and bear blue figures, of one shade, or of several, the second of these processes is had recourse to. Sometimes one or two colours are joined to the blue thus made; but in this case, they must be applied after the blue dyeing, because there is not a colour which may not be either destroyed,

or powerfully altered, in the operations which it requires.

Lastly, in other circumstances, a blue is to be put on cloth covered with a pattern, all of whose parts are already coloured, and which leaves merely small spaces to colour blue. For this purpose, the blue is used which is applied with the pencil (small brush).

This blue of application is thickened with gum, and put upon the pencil. It may be printed on, by covering with canvass the frame which contains the thickened colour, and removing the regenerated indigo with a scraper before applying the plate; but only small objects of a slightly intense blue, which rarely succeeds, can be thus applied.

Bancroft says, that he has substituted sugar for the sulphuret of arsenic with success; which would be advantageous, on account of the price and poisonous qualities of this substance. The experiment did not succeed with us.

The blue of application has been attempted to be prepared by means of the oxide of tin; but the degree of concentration of the alkaline solution adequate to the solution of the oxide and the indigo has not been hitherto ascertained, so as to be susceptible of thickening with the gums. This point once determined, a pencil blue will be had, which will possess the very great advantage of not occasioning a bulky deposite, which always embarrasses the vessels where this blue is made in the ordinary processes, and which, however

well washed, causes a considerable waste of the indigo.

In printing on cloth, ground indigo with oxide of tin, and passing the cloth through a solution of oxide of tin in potash, delft-ware blues may be made in a single vat. We have been able to make in this way only light blues. Were this process brought to the point of producing more substantial blues, it would afford great advantages.

CHAPTER IV.

Of Saxon Blue.

The name of *Saxon blue* is given to the dye for which solution of indigo in sulphuric acid is employed, because it was discovered at Grossenhayn, in Saxony, by Counsellor Barthe, about the year 1740. This discovery was kept secret for some time, but it gradually spread abroad. At first the solution was not made with indigo alone, but alumina and antimony were added, and other mineral substances besides, which were previously digested with the sulphuric acid. Indigo was afterwards added, and when the solution was complete, it was used for dyeing.

Bergman performed many experiments on this solution of indigo, which have thrown a great light, not only on its properties, but also on the

general cause of the fixation of the colouring particles on stuffs.

He employs, as has been stated before, one part of indigo well pulverized with eight parts of sulphuric or vitriolic acid, so concentrated that its specific gravity is to that of distilled water as 1.90 to 1.00. The mixture being made in a glass bottle, loosely stopped, a great heat is excited. After a digestion of 24 hours, at a temperature of 20° or 30° R., the indigo is dissolved, but the mixture is entirely black and opaque. On adding water it grows clear, and yields successively every shade of blue, according to the quantity of water. In a great number of experiments which this illustrious chemist describes, he kept in boiling water for 24 hours the stuff intended to be dyed: he then put a determinate weight of it into a bath of greater or less strength, till the bath was deprived of colour *(decoloré)*. It follows from his experiments, 1. That one part of indigo by this process can produce a black-blue on 260 parts of stuff, which seems to be then saturated, for it could take no more indigo in a permanent manner. 2. That the cold bath acts as well as the hot. 3. That the operation may be made without waste of indigo, for the bath can be entirely blanched; and if it has been too much charged, unsaturated stuff may be added, which absorbs all the remaining colour. 4. That the bath saturated with salt of soda (crystallized carbonate) yields only a very pale colour; and with the sulphate of soda it gives a bright blue,

but much less feeble, so that these salts unite more or less with this dye.

Similar experiments have been made on silk, which had, in like manner, been soaked in hot water, and which had been withdrawn from the bath after 144 hours. The indigo dye forms a blue on silk as on (woollen) stuff; but the affinity which precipitates the blue molecules is weaker. Although the patterns of silk resist water alone very well, they cannot bear the action of soap.

Threads and cotton took but very pale shades with this dye.

The deepest shades obtained by this process with the employment of concentrated sulphuric acid are not liable to change, according to the statement of Bergman. He says, that having exposed to the sun all the patterns during two months, the Persian and Turkey blues (Coventry blues) were scarcely impaired; but that the light shades suffered much more, growing dead and greenish.

Quatremere says, that among several dyehouses, he was acquainted with only two where the method of making the indigo dye, by sulphuric acid, penetrate into the interior of the stuff, or what is called pierce or cut *(percer ou trancher)*, was understood; and that he gave it this property by introducing fixed alkali into it, in the proportion of one part to one of indigo, with six of sulphuric acid. He has dyed with this preparation a sample of blue of the liveliest and deepest shade, and the section was as dark as the surface.

Poerner, who was much occupied with this preparation, recommends likewise the addition of alkali.* He says, that by this means the colours are more agreeable, and penetrate deeper. He further prescribes to take only four parts of sulphuric acid to one of indigo. In the process which he describes, four parts of concentrated sulphuric acid are poured on one part of indigo reduced to a fine powder. This mixture is stirred for some time, and then left at rest for 24 hours. One part of good dry potash in fine powder is now added to it. The whole is well mixed, and left at rest for 24 hours, after which a greater or less quantity of water is added to it.

The same author announces, that he has found a preparation of indigo in a dry form, which is more advantageous, and of more easy and convenient use than the preceding, but that he cannot communicate it yet to the public.

Bancroft adopts the proportion of sulphuric acid and indigo, as also the addition of alkali, recommended by Poerner. He says, that the sulphuric acid may be even diluted to a certain degree. He remarks, that the indigo of Guatimala is fitter for this solution than the others, ascribing this peculiarity to its being more oxygenated, because lime water was probably not employed in its preparation; on which account it was necessary to subject it to longer beating to effect its

* Instruction sur l'Art de la Teinture.

precipitation. The difference presented in this respect by Guatimala, might however be owing only to its affording less yellow extractive matter, and to its molecules offering in their cohesion less resistance to the sulphuric acid.

Bancroft states, that by precipitating the solution of indigo with carbonate of lime a blue precipitate may be had, which can serve for dyeing directly. This might possibly be the preparation announced by Poerner.

Bergman conceived, that the Saxon blue owed its little permanence merely to the too feeble concentration of the acid which he employed for dissolving it. But his trials must have led him into a mistake in this respect.

For regulating the preparation and employment of solution of indigo, what we have formerly laid down must be borne in mind.

The indigo suffers in this solution an alteration which cannot be avoided; but it should be so managed as to make it as small as possible. Consequently the heat should be tempered as nicely as may be, as well as the concentration and quantity of the sulphuric acid. When the solution is made, it is proper to dilute it with water, in order to preserve it, and to prevent the degradation making progress.

A small quantity of alkali may have good effects, but a greater would be injurious, since the alkali possesses the property of dissolving the blue molecules precipitated from the sulphuric acid. Thus, as Haussman observes, soap and

alkalies render stuffs dyed in Saxon blue yellow, and water alone is sufficient to separate the colouring particles fixed on cotton.

In the process commonly made use of for dyeing Saxon blue, the cloth is prepared with alum and tartar. A smaller or greater proportion of the indigo solution is put into the bath, according to the lightness or depth of the shade wished to be obtained. The name *composition* is given in the workshops to this solution, and occasionally that of *bleu de Prusse*, or Saxon blue. The clear shades may be made in the sequel of the deep shades, but they have more lustre when made in a fresh bath. For the deep shades, it is advantageous to pour in the solution of indigo by portions, lifting up the cloth on the reel.

Other details will be given on this dye, and particularly on the *English blue*, which is a modification of it, when treating of green in the Sixth Section.

CHAPTER V.

Of Dyeing Blue by means of the Prussiate of Iron.

As the prussiate of iron, or prussian blue, furnishes a beautiful and permanent colour to painting, attempts have been made to extend its use to dyeing. It was Macquer who sought to render

this substance useful to the art, after giving important observations on its nature.

The chemical properties of the principle which forms prussian blue with the oxide of iron, occasion very varied combinations and phenomena, of which we shall give merely such an idea as may be proper for regulating the operations in which it is employed.

This principle is derived from a combination which is formed when any charcoal containing azote, as that of animal substances, is calcined along with alkali, and then moistened. The water is decomposed; its hydrogen, on the one hand, forms ammonia with the azote, and, on the other, forms the colouring principle of prussian blue with azote and carbon, whilst its oxygen produces carbonic acid. If the charcoal has been exposed to too strong a heat, it is deprived of its azote, as Gay Lussac observed, and then it can no more produce either ammonia, or the colouring principle of prussian blue.

The name of *acid* is given to this colouring principle. It has not, however, of itself this property, but acquires it by combining with a metallic oxide, particularly the oxide of iron; for it then saturates the alkaline properties. As it is in this state that it exists in the alkaline prussiates, we shall call it by this name, without regard to its complex composition.

Whenever an alkali is made to act on the prussiate of iron, the prussic acid, which retains some

oxide of iron, saturates the alkali, and thus the prussiates of alkali are obtained. The oxide of iron meanwhile retains a certain proportion of prussic acid. This latter compound has a yellow colour. In this state an acid makes a partition of the oxide of iron, till the yellow prussiate be brought to the state of blue prussiate. At this term the acids can no farther destroy the combination, unless heat be employed.

The acids cannot all equally decompose the prussiates of alkali without an elevation of temperature, or without the agency of light. In this case a portion of the prussic acid assumes the elastic state, and volatilizes, whilst another falls down with the oxide in blue prussiate.

If a solution of iron be mixed with a prussiate of alkali, the oxide combines with the prussic acid, and precipitates; but it retains a portion of the alkali in its composition, so that the prussiate of alkali and prussiate of iron must be considered, both the one and the other, as triple combinations. In the one it is the oxide which predominates; in the other it is the alkali. Let us examine the methods by which we can fix this first combination upon stuffs.

Macquer's first attempt was to soak cotton yarn, wool, and silk, in a solution of alum and sulphate of iron; next in an alkaline solution, which was in part saturated with prussic acid; then in water soured with sulphuric acid, so as to dissolve the portion of the oxide of iron combined with the prussic acid, which had been precipitat-

ed by the alkali uncombined with this acid. He repeated the immersions successively, and obtained a fine blue, but very unequable. Wool and silk became rough to the touch by the action of the alkali, as well as by that of the sulphuric acid.

It is easy to see that this process ought not to have been successful; for as an alkali not saturated with prussic acid was used in a second immersion, the portion of unsaturated alkali must have dissolved more or less of the blue fixed in the first. If these experiments were therefore to be resumed, it would be requisite to employ an alkali saturated with prussic acid or lime water, and particularly magnesia, which have likewise the property of combining with this acid.

In a second process this able chemist boiled his patterns in a solution of alum and tartar, and turned them afterwards through a bath, in which he had mechanically diffused prussian blue. They were now dyed evenly, and were soft to the touch, but the shade was faint; nor was it possible to make it deeper.

Menon proposed another process for thread and cotton. It consists in dyeing the stuff at first black, and then letting it steep some minutes in a solution of prussiate of alkali. It is thereafter boiled in a solution of alum, where it takes a very deep blue. A blue combination is formed, and the alum dissolves the remaining black particles; but the effect must be very irregular, according to circumstances.

Several attempts have been made to derive advantage from these experiments, and especially from the first method; but whatever pains may have been taken, the colour was always faint, dull, and unevenly. This was given up in favour of a process which has a considerable relation to the second one of Macquer. The prussian blue is merely diffused in muriatic acid, which does not make a true solution, but attenuates it enough, by its affinity, to cause it to penetrate cotton goods more copiously. We shall now literally transcribe the description given of it by Roland de la Platiere,* which agrees with the practice of certain dyers.

On fine prussian blue powdered, passed through a very close sieve, and put into an earthenware vessel, in an indeterminate quantity, but in the proportion of half a kilogramme (about a pound) for every piece of goods, pour muriatic acid till the materials assume the consistence of syrup; stir continually while it is in fermentation (chemical action) for about half an hour; dilute well, and stir again from hour to hour, during a day, till finally no more fermentation is perceived. Thus the division of the particles will be very great, and their union with the acid intimate.

Into a trough narrower than the ordinary ones, and more widened out above, two feet and a half high, two feet in diameter at the bottom, and two feet and a half at the top, put from seven to

* L'Art du Fabriquant de Velours de Coton.

eight gallons of water for one piece of velvet; add to it some of the composition, previously well diluted with water in a separate vessel. Pour this into the bath through a very fine sieve; and as soon as the piece is arranged on the winch placed over the trough, rake the bath well, and let down the velvet quickly, working with the utmost possible activity, for one, two, or three hours, passing the piece in succession from the winch to the horse or board *(planche)*, and from the board to the winch.

As the prussian blue is not really dissolved, but only much attenuated, and as it is heavy, it falls down rapidly on the stuff *(matière)*, and always in larger quantity on the first that presents itself. It thus happens, that the colour is at first wavy, and often in patches *(placardée)*, whatever pains be bestowed. This should excite no surprise. Such accidents must, however, be avoided as much as possible, by working the stuff over and over again, washing with the bath itself the portions most stained, working over again, sometimes one end first, sometimes the other, and then drying; lastly, working anew, always as equally and quickly as possible. It may now be dried a second time, if necessary, and worked once more till the wished-for shade appear, and the colour be very even. This dye requires the most expert of workmen. Between each drying the stuff is washed and beetled. In all kinds of baths the stuffs must always be previously moistened. Were it dry, the bath would penetrate with

difficulty and great inequality. The last time they do not wash, but dry on the pole *(a la rame)* in the open air, either in sunshine or shade, provided the piece be well stretched.

This colour, one of the most beautiful that art can produce, is unalterable in the air, and in all weathers, when it is well done. Roland de la Platiere exposed several patterns of it for six months consecutively; the colour heightened *(raemonté)* for some time, and finally lost somewhat. The acids are not injurious to it; even boiling in alum affects it slightly; dust, however, and friction on the creases of it, soon makes it fade.

The methods heretofore pointed out for fixing the beautiful colour of prussian blue on stuffs, have not accomplished this object. The first, which form a combination, yield only a weak or very unequal colour; the last afford but a mechanical fixation of blue molecules, which a slight friction can separate. It has been attempted to give more effect to the method of combination.*

A combination can be produced between the prussiate of iron and a stuff, only when the oxide of iron is previously combined with the stuff, so as to receive the prussic acid, because it (the compound) is insoluble, resembling indigo in this respect; but on impregnating a stuff directly with a solution of iron, in order to combine it with the oxide of this metal, inequalities are

* Annales de Chimie, tom. xxi.

inevitable, which become very obvious when they are changed into prussiate. This inconvenience is obviated in dyeing the stuff first grey or a deeper shade, according to the blue wished to be obtained; for in this primary dye, a more uniform combination is made of oxide of iron and of astringent matter with the stuff.

An alkaline prussiate would not give up the prussic acid to the stuff; but on adding an acid, as the sulphuric, the action which this exerts on the base of the alkaline prussiate, determines the separation of the prussic acid, which now enters into combination with the oxide of iron united to the stuff, expels the astringent from it, and takes its place, forming a fine blue colour. All the alkaline prussiates may be employed with this view.

The process which has been pursued, consists in diffusing, in three or four parts of water, the prussiate of lime, or in dissolving a corresponding quantity of the prussiate of alkali in the water; in keeping the liquor at a heat of 20 to 30 degrees (R.), and plunging into it for some time the stuff previously dyed, of a shade more or less deep, from grey to black. It is proper to begin with soaking it in hot water, and on taking it out of the liquor, to turn it through cold water. Sulphuric acid answered better than the muriatic. This method may be especially useful for procuring fine greens. We shall treat of it elsewhere.

The trials were only made on cotton and silk. Bancroft has found the process equally successful with wool.

The property possessed by the prussiates, of forming blue by giving up the prussic acid to the oxide of iron, may render them useful on employing them in the same manner to restore the colour of black stuffs, whose astringent has been destroyed by age, and in which the oxide of iron, grown predominant, produces a russet hue. They may also deepen the imperfect blacks. Thus a mixture of blue and black is made, which increases, as we have seen, the intensity of the latter.

The products of the prussic acid process, which we have just now detailed, have the great inconvenience of being destroyed by the action of alkalies and soap, because the alkalies decompose the prussiate which is formed. This is a serious disadvantage, particularly for cotton stuffs. If it be used, therefore, on such stuffs, bran or other detergents should be employed, instead of soap, for cleansing them.

Bancroft has made several interesting experiments, with the view of applying the other metallic prussiates to stuffs. He obtained, in particular, a fine copper-red colour, by using solutions of copper. We have got this colour by impregnating cotton with a solution of copper, and following, in other respects, the process just described. Hatchet also made use of solutions of copper for forming, by means of the alkaline prussiates, a

prussiate of copper, of a red bordering on brown, which presented interesting properties when employed as a colour, (pigment).*

The celadon green was formerly given by means of sulphate of copper; but this colour, which approaches very near to blue, is not permanent, and is no longer in use. The processes employed in it may, however, be pointed out. The cloth, washed in the fulling-mill, and moistened with hot water, is turned through a well saturated solution of soap, for about an hour, when it is passed for half or three quarters of an hour through a solution of sulphate of copper or blue vitriol: by means of a net, the cloth is prevented from being made dull with the sediment of the soap and the sulphate of copper. Occasionally, for obtaining a more decided green, a solution of copper was mixed with the weld bath; sometimes verdigris was substituted for sulphate of copper.

Hellot describes a somewhat different process, by which the Dutch produced this colour in perfection. He says, that they mixed equal parts of lime and sulphate of copper in a bag; and that they turned the cloth out of the boiler which

* Bibliot. Britann. vol. xxii.

In the trials of the metallic prussiates, it must not be forgotten that the alkaline prussiates contain prussiate of iron, which falls down in the operation; whose colour may make that of the other prussiate to vary. If this be soluble, a result may be ascribed to it, which is in reality owing merely to the prussiate of iron.

contained the solution of soap into another adjoining one, where the particles of copper which escaped through the bag made it green.

The blue colours procured by means of logwood, of which we shall speak more particularly when treating of the properties of this colouring substance, cannot be compared in point of durability to those given by indigo and prussiate of iron.

SECTION III.

OF RED.

CHAPTER I.

Of Madder.

MADDER, a substance very extensively used in dyeing, is the root of a plant, of which two species are distinguished by Linnæus. The first, the *rubia tinctorum foliis senis;* the second, *rubia peregrina foliis quaternis.* The first has two varieties, the cultivated and the wild madder, also named *rubia silvestris monspessulana major.*

Although madder can grow both in a stiff clayey soil and in sand, it succeeds better in a rich (*grasse*), soft, moist, and very slightly sandy soil. It is cultivated in several of our departments. That of Zealand was generally regarded as the best which grew in Europe; but the madder cultivated in the lower departments of the Rhine is not inferior.

Madder, prepared for the purpose of dyeing, is distinguished into different qualities. That which

comes from the parent roots, (*mères racines*), is called *garance grape*; and *non grape* is the produce of the stems that sink into the earth, where they are transformed into roots, to which the name *couchis* (layers) is given. Each of these species is subdivided into *garance-robée*, *mi-robée*, and *non-robée*, short or male (*courte ou mâle*).

When the roots of the madder are plucked up, the *couchis* are separated to form the madder *non grape*, to which are joined the fibres that have not attained a certain size, as well as the roots which are too large, and contain much heart or ligneous substance. The best roots are those which have the size of a writing quill, or at most of one's little finger. They are semitransparent, and reddish, have a strong odour, and a smooth bark.

The madder, taken from the ground and picked, should be dried in order to be ground and preserved. It is dried in warm climates in the open air; but elsewhere stoves must be employed.

It results from this difference of preparation, or perhaps also from a variety in the plant, that two kinds of madder are distinguished, which differ in their dyeing properties.

The first, which is cultivated at Smyrna, in the island of Cyprus, and in the Levant, is known under the name of *lizari*. Its culture is established in our southern departments, where it is by no means of worse quality. We shall now take a summary view of the preparation to which it is subjected in our departments of the south,

agreeably to notes given us by Chaptal. We shall afterwards speak of the ordinary madder.

The roots are dried in the air, on a paved floor, or on a hurdle. They are stirred about with a fork, and slightly beat, in order to separate the epidermis (outer skin) and the earth. What remains on the ground, composed of earth, epidermis, and small roots, is sifted, and that left on the sieve forms what is called *billou*, common madder, which is fit for only dull colours. The roots of madder thus picked, are ground, either under a stone mill, or under knives similar to those of a bark mill (tan mill). By means of fanners or a boulter, there is separated, after a first milling, the madder called *non-robée*. It is composed of a residuum of earth, epidermis, and bark. After a second milling, what is separated is called *mi-robée*. Finally, after a third milling, the madder *robée* is obtained, which is of the best quality. The *mi-robée* is preferable, however, when it comes from somewhat thick roots. When milling is performed for one's own use, only one quality is made; or if a very brilliant colour be wanted, the worst quality is separated by a first grinding, and the product of the second is employed. This is called in the south, *grappier*.

The roots of good quality are of middling size, little branchy (*peu rameuses*), and their fracture is of a lively reddish yellow. Such as grow wrinkled in the course of drying are not good. For the madder to be properly ripened, it should have

reached its third year, and be plucked in the fourth.

The preparation of madders is carried on in the departments of the Rhine, by more numerous operations.

The roots are dried in a stove, heated by means of a furnace, from which the air is allowed to issue only at intervals, at the moment when it is judged to be saturated with moisture. The furnace (flue) occupies a great portion of the floor; above, are three open floors, on which the roots are distributed in layers of about two decimetres (nearly 8 inches). At the end of 24 hours, those which are on the first stage (or floor) directly above the stove are dry, when they are taken away and replaced by those of the superior floors. This operation is repeated whenever the roots over the stove are dry. The dry roots are thrashed with a flail, passed through a *talard* similar to that employed for corn, and then passed through a very coarse sieve. What passes through is farther thrashed, *talardé*, and sifted through a finer sieve than the first. These operations are repeated five times, proceeding successively to sieves still finer and finer, and setting aside every time what remains on the sieve. What passes through the fifth sieve is rejected as sand and dust. After these operations, the whole roots remaining on the sieve are cleaned with common fanners, and women separate all the foreign matters which had not been removed before. For dividing the roots, thereafter, into different qualities, a brass sieve is

made use of, whose meshes are from six to three millimetres in diameter (from 1-4th to 1-8th inch, E). What passes through the finest is rejected; and what passes through the coarsest is regarded as of the best quality. These roots, thus separated, are carried into a stove, of a construction somewhat different from the first. They are spread out in layers of about a decimetre in thickness, (nearly 4 inches E.), on large lattice-work frames, and the drying is known to be complete, when on taking up a handful and squeezing it, the roots break easily. On quitting the stove, the madder is carried, still hot, into a machine, where it is rasped (*rapée*), and a sieve separates the portion of the bark reduced to powder. This operation is repeated three or four times, then the boulter is had recourse to. What passes through the sieve, or the brass meshes of the boulter, is regarded as common madder, and what issues at the extremity of the boulter is called the flour. Lastly, the madder which passes through the boulter is ground in a mill with vertical stones, and then passed through sieves of different sizes. What remains above is always better than what goes through.

The madder of Alsace is reduced to an extremely fine powder, and its colouring matter is extracted by a much longer ebullition than is necessary for the *lizari*. The prepared madders ought to be carefully preserved from humidity, because they easily imbibe moisture, in which case fermentation spoils their colour.

D'Ambourney and Beckman have asserted, that it is more advantageous to employ the fresh root of madder than what has been submitted to desiccation, especially by means of stoves. But in its state of freshness, its volume becomes troublesome in the dyeing bath, and uniform observation seems to prove that it ameliorates by age. Besides, it must be rendered susceptible of keeping and carrying easily.

The celebrated Watt made experiments on a very choice madder from Zealand, which are well adapted to display the properties of its colouring particles. We shall detail them.

A. This madder is of a brownish orange colour, and of the consistence of a coarse powder, possessing a slight degree of cohesion: it attracts moisture, in which case it loses its properties, so as to become unfit for the purposes of dyeing.

B. With water it affords an infusion of a brownish orange colour; its colour cannot be extracted without a copious addition of water. Margraff directs three quarts of water for two ounces of madder. Its colouring particles may be extracted either by hot or cold water; to the latter it appears to give a more beautiful colour; its decoction is brownish.

C. When an infusion or decoction of this drug is slowly evaporated in an open vessel, a pellicle is formed on the surface, which gradually falls to the bottom; after which fresh pellicles are successively formed until the evaporation is finished.

D. The extract thus prepared is of a dark brown; it partly dissolves in water, to which it communicates a lightish brown colour.

E. The infusion set to digest for some days in an open vessel, which should be of such a height that the liquor reduced to the form of vapour may fall back again, deposites dark brown pellicles. The liquor remains of a brownish colour, and the pellicles are soluble in water, but with difficulty.

F. Alum forms in the infusion B a deep brownish red precipitate, composed of pellicles, and the supernatant liquor is of a yellow colour, inclining to brown.

G. Fixed alkalies precipitate from this last liquor a lake of a blood-red colour, which has greater or less intensity, according to the quantity of alum that has been dissolved in it. In this way, a blood-red lake may be obtained; but we cannot, by any means hitherto known, give it the brightness of cochineal lake: in oil it is transparent, but in water it is opaque, and without beauty.

H. If a superabundant quantity of alkali be employed, the precipitate is redissolved, and the liquor becomes red.

I. The lake precipitated by potash is of a more beautiful colour than that by soda.

K. Calcareous earth precipitates a more dark and brown coloured lake than alkalies, particularly if it form lime water.

L. If a few drops of alkali be added to the water employed in making the infusion B, the infusion extracts many colouring particles of a deep red, bordering on brown. 1*st*, Alum precipitates a deep brown lake from this infusion. 2*dly*, Acids added in small quantity change it to a yellowish colour, and in greater quantity render it a brown-yellow; but they precipitate nothing from it. 3*dly*, This infusion evaporated to dryness, forms a gummy extract, which easily dissolves in water.

M. If the infusion B be made with water very slightly acidulated with a mineral acid, it is yellowish. 1*st*, This liquor, by long digestion, becomes of a greenish-brown, and the yellow appears to be destroyed. 2*dly*, The addition of an alkali restores the red colour; and the infusion then affords, on evaporation, an extract, which readily dissolves in water.

N. If carbonate of magnesia be added to the water used for the infusion B, the infusion is of a clear blood-red, and on evaporation forms a blood-red extract, which readily dissolves in water. 1*st*, A solution of this extract, which is employed as a red ink, when exposed to the light of the sun, becomes yellow. 2*dly*, Alum precipitates from this infusion a small quantity of an ill-coloured lake. 3*dly*, Alkalies give it a redder and more fixed colour.

O. If the infusion be made with a solution of alum, it is of an orange-yellow. This infusion,

precipitated by an alkali, affords a lake resembling that of F, but its colour is not so good.

P. A solution of sugar of lead, added to the infusion B, forms a brownish-red precipitate. 1*st*, A solution of mercury in the nitric acid, gives a purple-brown precipitate. 2*dly*, A solution of sulphate of iron, a fine bright brown precipitate. 3*dly*, A solution of sulphate of zinc has not been tried. 4*thly*, A solution of sulphate of manganese, a purple-brown precipitate. 5*thly*, A solution of iron in aqua regia has not been tried.

Q. The infusion B being mixed, while hot, with the infusion of cochineal, a brownish-red precipitate, bordering on a deep purple, was formed, of difficult solubility in water. By continuing the digestion, a greater quantity of this precipitate appeared. 1*st*, A pattern soaked in the preparation which the linen-printers use, having been dyed in this mixture, took a brownish-red colour; and after having been boiled in a solution of soap, the colour appeared pretty good. 2*dly*, The solution of soap became very red, but communicated a very indifferent colour to paper.

M. Merimé, a painter, who seeks to render physical science subservient to his art, has made some interesting experiments on madder, the object of which was to procure a lake, uniting durability to lustre. The results of these experiments, which he has communicated to us, may possibly be useful in dyeing.

The pellicle, which serves as a bark to the madder root, was separated from its pulpy and ligneous part, and he obtained from both a lake whose lustre approaches to that of carmine, but which is much more durable when he previously submitted them to immersions and lotions, so as to remove a dun colouring substance. The bark, however, yielded less than the ligneous portion. After the preliminary immersions, he digested them in a feeble solution of sulphate of alumina; after which he precipitated by alkali this solution, which varied in the depth of the shade.

It appears then that madder may be considered as composed of two colouring substances, one of which is dun (tawny), and the other is red. Both of these substances may combine with the stuff. It is of consequence, however, to fix only the red part. The dun portion appears to be more soluble, but its fixity on stuffs may possibly be increased by the affinity which it has for the red portion.

The different additions made to madder, and the multiplied processes to which its dye is sometimes exposed, have probably this separation for their chief object.

The red portion of madder is soluble, but in small quantity, in water. Hence, a limited concentration can be given to its solution. If the proportion of this substance be too much increased, so far from obtaining a greater effect, we merely augment the proportion of the dun part, which is the more soluble of the two.

The red part appears to be especially apt to form the pellicles observed by Watt. De Saussure has shewn, that during the formation of these pellicles in the extracts of vegetable substances, for which the contact of air is required, the oxygen gas is changed into carbonic acid; that water is at the same time formed by the more intimate union of the oxygen and hydrogen contained in the substance, and that the residuum thereby gets an excess of carbon; so that in the experiments of Watt these pellicles dissolved but partially, and their solution was brown. The red particles, therefore, lose their solubility, and become brown by ebullition, without the influence of atmospheric air. The cause of this last alteration is not hitherto determined by experiment.

Potash, and carbonate of potash, augment the solubility of the two colouring parts, without accelerating the effect of oxygenation; thus, it would seem to be advantageous to add a small quantity of alkali to the madder baths.

The solution of tin affords lakes devoid of lustre, probably because the two species of colouring matters are precipitated together. This mordant, of so great advantage in a great number of dyes, can hardly be useful in those of madder. We shall see, however, that it is capable of heightening the brilliancy of the Adrianople red; but at a period of the operation when the dun part has been removed.

The considerations which we have just now presented, are, in part, nothing but conjectures, towards explaining the properties observed in the different processes to which madder is subjected. We suppose, for example, the existence of two species of colouring particles; but these may possibly be derived from a single one, which, by the successive operations that it undergoes, is resolved into two.

CHAPTER II.

Of the Processes used in dyeing with Madder.

Wool would take with madder only a weak and perishable dye, were not the colouring particles fixed by a base, which combines them more intimately with the stuff, and which screens them in part from the destructive action of the air. For the accomplishment of this object, the stuff is, first of all, boiled with alum and tartar, for two or three hours; after which it is drained, slightly wrung, then enclosed in a bag, which is carried into a cool place, and let alone for some days.

The dose of alum and tartar, as also their relative proportions, vary much in different dyehouses. For one pound of wool, Hellot adopts a little less than the third of alum and tartar. If the proportion of tartar be increased to a certain degree, instead of a red, there would be obtained merely a deep, but durable cinnamon colour; because

the acids tend, as we have seen, to give a yellow hue to the colouring portion of madder. Poerner diminishes somewhat the proportion of the tartar; of which he prescribes only one-seventh of the alum. Scheffer, on the other hand, prescribes a quantity of tartar double that of alum. But it has been ascertained, that by employing one-half of tartar, the colour inclined more to the cinnamon than when it had been reduced to one-fourth of the alum.

Ebullition must be avoided for the dyeing bath into which merely madder has been put, because at this degree of heat the colouring substance is easily spoiled, and assumes a deeper hue.

When the water is no hotter than the hand can endure, Hellot directs to throw into it one part of the finest *grape* madder for two parts of the wool to be dyed, and to rake well before introducing the wool, which must be kept an hour in it without making the bath to boil; but to render the dye faster, it may be boiled towards the end of the operation for three or four minutes at most. Beckman recommends to add a little alkali to the madder bath.

By this process, reds are obtained which are never so beautiful as those of kermes, and much less so than the lac and cochineal ones; but as they cost little, they are employed for common stuffs, which could not bear the expense of a dearer dye. The madder reds are occasionally rosed with archil and brazil wood, to make them

more beautiful and velvety; but the lustre lent by this means is not lasting.

Poerner, Scheffer, Bergman, have employed solution of tin in different modes; but our own multiplied experiments do not confirm the advantage of these processes.

Madder does not afford a colour of sufficient brilliancy for dyeing silk, and we conceive it useless to detail the processes which Lafolie, Scheffer, and Giobert have given on this subject.

Madder is employed for dyeing linen and cotton red, and even for giving them several other colours, by means of different mixtures. It is the colouring drug most useful for this kind of dyeing. It is proper, therefore, to shew in sufficient detail the different methods by which this dye may be rendered more permanent, beautiful, and diversified in its effects. Linen takes the colour of madder with more difficulty than cotton; but the processes which succeed best with the one, are also preferable for the other.

Two species of madder red on cotton are distinguished; the one called simply madder red, the other possessing far more lustre, is called Turkey red, or Adrianople red, because it was for a long time obtained from the Levant.

We may also regard as a distinct dye, that employed in calico printing. These three kinds of processes now to be described, may mutually throw light on one another, and serve to determine the most proper means for accomplishing the object of each.

Vogler has tried the effect of a great number of the substances employed as mordants, or in the dyeing bath, and he found that those which produced the best effect were glue, ox-gall, and other animal matters, as sheep's dung. Muriate of soda rendered the colour faster, but more dull. Galling, likewise, procured a richer colour (*plus nourrie*). Other astringents, sumach, and pomegranate rind, for instance, produced a similar effect. A little alkali added to alum improves it. A small quantity of tartar has been useful, but too great a proportion of tartar, as well as of other acids, makes the colour pass to yellow. Different metallic salts produced some variations in the shades and solidity, but not remarkable enough to deserve notice. In speaking of black, we have detailed the process which Vogler indicates for dyeing cotton black by means of madder. He justly remarks, that drying is useful between each operation, after rinsing the cotton on its quitting the bath. This drying ought to be performed in the shade, especially when alum is employed, because when too much of this is thrown down on the stuff, it crystallizes on its surface. He further remarks, that an ebullition of too long continuance in the madder bath destroys the colour with which the stuff is charged.

In the experiments of Vogler, cotton took the colour always better than thread (linen); the difference, however, was not very great, when the subject was a hempen or woollen cloth, a little worn, and become soft to the touch; and when

its texture was very loose, or the yarn was slightly twisted.

Le Pileur d'Apligny gives a very detailed description of the process followed at Rouen, for dyeing cotton red. We shall copy it.

The cotton must be scoured *(decreusé)*, then galled in the proportion of one part of nut-galls for four of cotton, and lastly alumed at the rate of one of Roman alum for four of cotton, and the same proportion of water. To the solution of alum there is added one-twentieth of a solution of soda, made with one-fourth of a kilogramme of ordinary soda per litre.

Some persons put in one-half less soda, and diminish the water by a sixth, replacing the difference by a solution of tartar and arsenic. Le Pileur d'Apligny considers the last ingredients to be hurtful.

When the cotton has been withdrawn from the mordant, it is gently wrung with the pin, and dried. The more slowly the drying takes place, the more beautiful is the colour. Usually only ten kilogrammes of cotton are dyed at a time, and it is even more advantageous to dye no more than one half; because, when too many hanks are worked in the copper, it is more difficult to dye them uniformly.

The boiler in which this latter quantity of cotton is dyed, should contain about 240 litres of water. It is to be heated; and when the hand can hardly be suffered in it, three kilogrammes of good *grape* madder of Holland are to be put

in, and carefully distributed through this bath. Whenever it is well mingled, the cotton is to be plunged into it, hank by hank, previously passed over the sticks, and allowed to rest on the edge of the boiler. The whole cotton having been plunged in the bath, the hanks are worked and turned in succession round every stick, during three quarters of an hour, preserving the bath always at the same degree of heat, without letting it boil. On the expiration of this time, the cotton is lifted up, and withdrawn on the edge of the boiler. About half a litre of the soda ley above-mentioned, is now poured into the bath. The cotton is again let down into the copper, and is boiled in it for twelve or fifteen minutes. Lastly, it is lifted out, drained, wrung, washed in the river, and wrung a second time on the pin.

After two days a second maddering is given to this cotton, at the rate of one-half its weight of madder, working it in the same way as for the first maddering, only no ley is added, and pit-well water is used for the bath. This maddering being finished, the cotton is allowed to cool, washed, wrung, and dried.

Le Pileur d'Apligny thinks that this method of dyeing at two baths is not beneficial, because it wastes more time and fuel, and because the second maddering cannot afford much dye, the salts of the mordant having been exhausted by the first. He proposes another method, already pursued, he says, with success, by several dyers. It

consists in giving two alumings to the cotton, and then dyeing it in a single bath.

To brighten this red, a quantity of tepid water, sufficient to soak the cotton, is put into a boiler or a tub. About half a litre of ley is poured over it. The cotton is dipped in this bath, by portions, left there an instant, lifted out, wrung and dried. According to Le Pileur d'Apligny, this brightening is a useless operation. As the red cotton (yarn) is intended for making cloth, from which the dressing *(l'apprêt)* must be partially removed after it is woven, the colour of the cotton is brightened at the same time, by being turned through hot water, quickened with a little ley. On taking them out of this water, these cloths are washed in the river, spread out on the grass, where the red brightens much better than it could do by any other operation.

Wilson rightly prescribes the use of the mordant, known by the name of calico-printers' mordant, which will come under our consideration in dyeing cotton red. By his process, it is requisite to gall, dry, impregnate with a mordant diluted with hot water, dry again, madder, wash, and dry.

The mordant employed for producing reds on printed goods, is the acetate of alumina, prepared by the processes already described, and more or less concentrated, according to the intensity of the shade wished to be obtained.

When the goods have undergone the desiccation, which ought always to follow the printing

on (of the mordant), they are turned through a boiler, which contains cow dung diffused through water. For the mordants intended for light shades, it is proper not to leave the cloth in it more than five or six minutes, at a gentle heat, not exceeding 45° R. The heat may be increased, and the duration of the dunging, for mordants which are to produce deep colours; but, in all cases, it is to be conducted with great circumspection, because, by pushing it too far, the mordant is removed from the cloth, and by doing it too little, the mordant not combined with the stuff, which lies loosely on it, afterwards impoverishes the dyeing bath, and fixes on the portions of the cloth, which are to remain white, some of the colouring matter that cannot be completely destroyed, without affecting the colour very considerably.

For maddering, the madder is carefully mixed with the hot water of the boiler, immediately after kindling the fire beneath it, and the cloths being attached to each other at their ends, are introduced. They are kept in motion during the whole time that the maddering lasts, so as to be evenly dyed, with which view they are passed round a winch that may be turned by a child. The fire is to be gradually raised, so that the bath be brought into ebullition in three quarters of an hour, or an hour at farthest. At this period the operation should be stopped the instant that the colours on the cloth have assumed the suitable shade; but if the shades be deep, the

maddering may, without inconvenience, be prolonged till the bath becomes dirty, and changes to a tawny hue. In this case, even two madderings should be given to the cloths, dividing between them the quantity of madder requisite for giving the colour all its intensity; for the colouring matter of the madder is spoiled by ebullition; and by thus prolonging it, as would be necessary were the whole madder employed in a single bath, we should not only fail in raising the colour, on account of the alteration which the colouring matter experiences, but at a certain term even what had been already fixed on the cloth would be degraded, and thus we should obtain colours which are neither sufficiently deep (strong) nor bright.

By adding a little potash to the madder the moment it is put into the boiler, the solution of the colouring matter is facilitated, and the colours are more speedily raised. The addition of a certain quantity of chalk appears to brighten the colours a little, especially when they are faint: bran is much more efficacious, and ought not to be neglected when light and brilliant hues are wanted. If the maddering have been well managed, the white ground may be afterwards restored, by passing a single time through bran, and then exposing on the grass.

Immediately after the maddering, the goods are washed and passed into coppers, in which bran is boiled in water; they are laid out on the grass; and these two operations are alternately

repeated, till the unprinted parts of the cloth have recovered their whiteness.

The maddering of printed goods requires pains and precautions, which long practice alone can teach. The causes which make their effects to vary, are too numerous for us to point them all out here. The quantity of madder employed, the duration of the maddering, the manner of managing the fire, are, along with the dunging, the circumstances which have most influence; and they cannot be subjected to any rule, because they must differ more or less in almost every process.

It is plain, that all these operations have for their objects; 1*st*, to remove the mordant uncombined with the cloth; 2*d*, to fix the colouring matter; 3*d*, to carry off, by the action of the air and bran, the dun colouring matter which is mixed with the madder, as well as the colour which covers the parts of the cloth not impregnated with mordant.

The cloths intended for printing ought to be very carefully bleached. The more perfect the white is, the more lustre do the colours take, and the more easy is the unmaddering. The fine whites on sale, are not even sufficient; and it is right to give them, at least, one ley, one exposure on the grass, or one immersion in oxygenated muriatic acid, and to let them also soak some hours in water acidulated with sulphuric acid. Very frequently, several leys and several immersions must be given. Thus the dressing (paste)

is completely removed, the remaining colouring matter of the cloth is destroyed, which, by fixing in a very durable manner that of the madder, might render the unmaddering a difficult operation; and thus also the greater number of the stains formed during the maddering, to which the name of madder spots are given, are prevented.

These stains, almost indelible, very common on certain kinds of cotton cloth, and of a colour perfectly similar to what madder gives to those parts of the cloth impregnated with oil, seem to arise from a combination with grease or oil, analogous to what takes place in the preparations of Turkey red. It is very probable that they are produced by the grease employed in the *parou*, or by the soap which must be employed in bleaching. The combination which in that case may be formed on the stuff, resists the subsequent operations well; and it will be seen, in the process for the Adrianople red, that the action of alkaline solutions, even pretty concentrated, is insufficient to destroy the combination of the oil with the cotton.

A strong ley, run off very hot, does not afford a complete guarantee against these spots, although it may be the surest means of avoiding them. It would be of great consequence for calico printers to be able to exclude from weaving and bleaching both grease and soap.

The Adrianople red has a lustre, which it is difficult to imitate by all the processes hitherto described. It has, besides, the property of resisting more completely the action of the different

reagents, as alkalies, soap, alum, acids. Vogler acknowledges, that by his numerous processes he has not been able to obtain a red possessing a durability equal to that of Adrianople, although he formed one much more permanent than the false Adrianople reds, which are often used for the *siamoises* and other red goods.

Aquafortis (dilute nitric acid) is, according to the same author, the surest and most expeditious means for distinguishing the true red of Adrianople from the spurious. It is sufficient to plunge a thread of the latter into it. It is soon seen to grow pale, and in less than a quarter of an hour it becomes white, whilst the true Adrianople red remains an hour without being affected, and it never loses the colour entirely, which only turns orange.

The Adrianople red, which for a long time came to us through our Levant trade only, stimulated the industry of our artisans; but the attempts were for a long time fruitless, or success was confined to a small number of dyehouses. Abbé Mazeas published experiments which threw much light on this dye; and the government promulgated in 1765, from information that it had procured, an *instruction*, under the title of *Memoir, containing the process for the incarnate cotton red dye of Adrianople on cotton yarn.* The same description is found in the treatise of Le Pileur d'Apligny; but this process has not completely succeeded. It appears that the fault consisted principally in the too great concentration of the

alkaline solutions. A mystery is made in the different dyehouses of the changes introduced into the process, by means of which more or less success has been obtained. We shall now give the description which Clerc, who conducted with success a manufacture of this kind at Vaudreuil, communicated to the author of these Elements, (Berthollet, sen.), and which appears to differ very little from the most usual practice.

Process of the Adrianople, or Turkey Red.

LET there be 50 kilogrammes of cotton to dye. We must begin by scouring it well. This operation is performed by boiling the cotton in a copper with a soda ley, at one degree of the areometer of Baumé; and there is usually added the remainder of the bath which has served for passing the cottons through *in the white preparation*, (*en l'apprêt blanc*), which is called *sickiou.*

For scouring the cotton properly, and preventing it from entangling, a cord is passed round three hanks, (the hank is composed of four skeins or knots (*pentes*), which weigh altogether half a kilogramme). It is thrown into the copper when the ley begins to boil. It is carefully immersed, so that it may not be burned upon the sides of the boiler, which should hold about 600 litres for 50 kilogrammes of cotton. The cotton is perfectly cleansed when it sinks of itself in the copper. It is then taken out and washed knot by knot (*pente par pente*) in the river. Lastly, it is wrung and stretched out to dry.

Second Operation.—Dung Bath.

Put into a tub 50 kilogrammes of Alicant barilla, reduced to coarse powder. This tub must be pierced with a hole near its bottom, that the liquid may run from it into another tub placed

beneath. The barilla being in the upper tub, about 300 litres of ley water are poured over it. When the water which is let off into the inferior tub marks two degrees on the *pèse-liqueur* of the soap-boiler, it is fit for the dung bath, which is made in the following way.

From 12 to 15 kilogrammes of sheep's dung are set to steep in a large earthen vessel, in the ley of two degrees, and it is broken down with a wooden pestle. It is then passed through a hair sieve placed over the vat in which the bath is to be prepared. Into this vat 6¼ kilogrammes of olive oil of Provence are poured, stirring well with a rake, in order to mix the oil with the soda ley and the dung. Some of the soda ley is poured over it. There are usually required nine pailfuls of water to soak 50 kilogrammes of cotton, (the pailful containing 16 litres). When the bath is thus prepared, the cotton is to be passed through it.

For this purpose some of the bath is lifted in a wooden bowl, and poured into an earthen vessel, built at a convenient height for working easily. A hank of cotton yarn is taken and worked well with the hands. It is lifted up several times, turning it about in the vessel, and afterwards hung up on a wooden hook attached to the wall. It is slightly wrung out, and thrown on a table. The same operation is repeated on each hank. The table on which the cotton is thrown should be raised two or three decimetres (about 10 inches) from the ground. A workman takes a

hank in each hand, and strikes it on this table to extend the threads. He changes the side (turns it over) three times, afterwards makes a small twist to form a head to the hank, and lays it flat on the table. Not more than three hanks should be put on one another, because too great a load would squeeze the bath out of the under hanks. The cotton must remain on the table 10 or 12 hours; after which it is carried to the stretching (frames), in order to be dried.

Third Operation.—Bath of Oil, or White Bath.

The ley of soda of two degrees of the *pèse-liqueur* is taken; and after cleaning thoroughly the tub in which the dung bath stood, there is put into it 5¼ kilogrammes of olive oil, and the soda water is poured over it, working (*brassant*) well with the rake (paddle), in order to incorporate the oil. This bath should resemble thick milk; and, when good, the oil must not separate at its surface. Some of this bath is next put into the earthen vessel, and the cotton is turned through it hank by hank, as in the preceding operation. It is thrown upon a table, and *creped*, (that is, beat on the table), and thereafter left on the table till next day, when it is taken to the stretching to be dried.

N. B.—About eight pailfuls of ley are required for this bath.

Fourth Operation.—First Salt.

On the soda sediment (*marc*) in the tub, fresh soda is put, if the water poured over the former has not three degrees. For this operation eight pailfuls of soda ley must then be taken, which are poured into the tub over the remainder of the white bath; and the cotton is passed through it as above. This operation is called *giving the first salt.* The soda ley has three degrees.

Fifth Operation.—Second Salt.

The cotton is passed through a soda ley of four degrees, with the same mode of working as above.

Sixth Operation.—Third Salt.

The cotton is passed through a soda ley of five degrees.

Seventh Operation.—Fourth Salt.

The cotton is passed through a soda ley of six degrees; and after being worked with the same pains, it is carried to the stretching to be dried on well smoothed poles. When the cotton is dry, it is taken to the river to be washed in the following manner.

Eighth Operation.

The cotton is to be steeped in water, then withdrawn, and allowed to drain on the horse (*bayard*). Water is thrown on it repeatedly, and at the end of an hour it is washed, knot by knot, to free it thoroughly from the loose oil,—a circumstance very essential for its taking the galling well. It is now wrung with the jack and pin, and stretched on the poles to dry. The cotton, when thus washed, should be of a beautiful white.

Ninth Operation.—Galling.

For the galling, good nut-galls in sorts (a name known in commerce, the galls in sorts being one-half black galls, and one-half white) should be chosen, and after having bruised them, for 50 kilogrammes of cotton 6¼ kilogrammes are to be put into a copper, and boiled with six gallons of pure river water. Three hours are commonly required for boiling them well. The decoction is perceived to be properly done when the galls are easily crushed under the fingers like pap. Three gallons of fresh water are now to be poured in, and the decoction is then to be passed through a very close hair sieve, kneading the pulp in the hands to extract the whole substance (*partie resineuse*). When the water is settled

and clear, the galling is to be performed in the following manner:—

Into an earthen vessel, fixed in the wall at a convenient height for working, from nine to ten litres of the nut-gall liquor are poured, and the cotton is passed through it hank by hank, squeezing it well with the fists, then wringing it with the pin; and in proportion as this is gone through it is immediately carried to be stretched and dried,—an essential precaution, which prevents the cotton from blackening. When the cotton is dry, the aluming is to be performed in the following manner:—

Tenth Operation.—Aluming.

After thoroughly cleaning the copper in which the decoction of galls was made, eight gallons of river water, and nineteen kilogrammes of Roman alum are introduced, and dissolved without boiling. When the solution is complete, half a gallon of soda ley of four degrees of the *pèse-liqueur* are poured in; and through this, the cotton is passed hank by hank as for the galling. It is afterwards stretched out to dry. It is washed from the alum as follows:—

Eleventh Operation.—Washing from the Alum.

After having allowed the cotton to steep, and drained it an hour on the horse (*bayard*), each hank is to be three times separately washed, then

wrung with the pin, and taken to the tenter ground.

Twelfth Operation.—Remounting on the Galls, (Remonter sur Galle.)

This operation consists in a repetition of the preceding ones. A white bath is prepared like that described in Article 3.; 6¼ kilogrammes of good fat oil of Provence are put into a tub, and eight gallons of soda ley are poured over it, of two degrees of the *pèse-liqueur* of the soap-boilers. Care is taken to stir the bath well, and the cotton is passed through it, as has been described in the 3d Article.

Thirteenth Operation.—First Salt.

The cotton, after being well dried, is passed through soda ley of three degrees.

Fourteenth Operation.—Second Salt.

The cotton being dried, is passed through soda ley of four degrees.

Fifteenth Operation.—Third Salt.

The cotton is passed, when dry, through a soda ley of five degrees, when all the dips are finished. It is now dried, washed, galled, and alumed with the same doses and the same atten-

tions described in Articles 9, 10, and 11. The cotton has then all the necessary preparations for taking the dye well. The cotton, on quitting these preparations, should be of the colour of the bark of a tree. A very essential point to be observed, is to submit the cotton to no dip till it be perfectly dry, without which there would be a risk of the dye being mottled. When the cotton is stretched on the poles, it must be carefully shaken, and turned over to dry it uniformly.

Sixteenth Operation.—Dyeing.

A copper of an oblong square form is usually employed. It should hold about 400 litres of water, and at this rate 12½ kilogrammes of cotton may be dyed in it at a time. To commence the operation of dyeing, the boiler is to be filled with water to within four or five inches of the top; there is next poured into it a pailful of ox-blood, or sheep's blood, which is better when it can be had, containing about 25 litres of blood. The *lizari* (fine madder) is now introduced. When a fine lively striking colour with much body is wanted, several lizaris are mixed together; for instance, 3-4th kilogramme of lizari of Provence, and 1-4th lizari of Cyprus; or if there be none of Cyprus, equal parts of the lizari of Provence, Tripoli, or Smyrna. The dose is always two parts to one of cotton. When the lizari is in the copper, it is stirred with a rake to break down any lumps; and whenever the bath is tepid,

the cotton stretched on skein sticks, called *lisoirs*, is plunged into it. Two hanks are usually put on each stick. Care should be taken to immerse it well, and that the cotton be turned round the *lisoirs*, end for end, by means of a pointed stick passing between the hanks and the *lisoirs* that the cotton rests upon. This operation lasts an hour; and when the copper begins to boil, the cotton is taken off the *lisoirs*, and plunged into the copper, each hank being suspended by means of a cord passed through it to sticks supported over the copper. The cotton should be kept boiling for about an hour, in order to extract the whole colouring substance of the madder. There is a method besides, of ascertaining when the colour is extracted; for a white froth then forms on the copper. The cotton is now tossed out of the boiler, and washed skein by skein in the river; then it is wrung with the pin, and hung up to dry.

Seventeenth Operation.—Brightening.

Into the boiler employed for the scouring (*decreusage*), which should be capable of holding 600 litres of water, soda ley of 2° of density is poured, with which it is filled to within 10 or 12 inches of the top. There is next poured in from 2 to 2½ kilogrammes of oil of olives, and 3 kilogrammes of white Marseilles soap sliced very fine. The whole is well stirred till the soap be melted; and when the copper begins to boil, the

cotton is introduced, a cord being previously passed through it to prevent its entanglement. The copper is covered up, its lid is stuffed with old linen, loaded, and made to boil with a small fire for four or five hours. The copper is then uncovered, when the cotton should appear finished, and of a beautiful red. The cotton should not be withdrawn from the copper till the end of 10 or 12 hours, because it becomes richer in the brightening, and takes more lustre.

It must thereafter be well washed, skein by skein, and dried, when the operation is complete.

I am in the habit of giving my cottons one dip after they are well dried. It consists in making a solution of tin in aquafortis, with 1-16th of sal ammoniac. I dilute this solution with eight pailfuls of water, and I pass my cotton through it. It must be afterwards washed. This dip gives a very fine fire (*feu*) to the cotton.

N. B.—Into the *sickiou* tub only the remainder of the first preparations (*apprêts*) is put. What remains after the cotton has been galled is good for nothing, and must be thrown away.

Chaptal, whose researches and enlightened zeal for the advancement of the arts have contributed so much to their progress, has had the kindness to communicate to us the notes which he had collected in his dyehouses, near Montpellier. We have extracted from them the following processes for dyeing Adrianople red, which he has long practised himself with much success.

The first precautions to be taken in this dye, consist in the good choice of materials. The fittest oil for this operation is what comes from the river of Gênes, under the name of dyeing oil. Some is also brought from the south of France. To try these oils, some drops are poured into a glass so as to cover its bottom, and it is filled up with soda ley, marking from 1° to 2° on the areometer of Baumé. The mixture becomes milky; this soapy liquid is transferred several times from one glass into another, in order to mix it well. It is then left at rest for several hours. The liquor should remain uniformly milky, provided the oil be good; if it separates in little drops, or if the bottom of the liquor assumes the appearance of ill clarified whey, while on the top a pasty zone (*bourlet*) forms, the oil is of bad quality.

The sodas (barillas) of Spain, Alicant or Carthagena, are to be preferred. In absence of these, that of Narbonne may be used. Good soda should be very hard, grey outside, blackish in its fracture, difficultly pulverizable, and soluble. Such as have effloresced in the air, and in which muriate of soda abounds, cannot be employed for fine colours.

In the operations about to be described, the proportions are given for one portion of cotton weighing 100 kilogrammes.

The cotton is scoured (*decreusé*) by boiling it in a soda ley, which marks from 1° to 3° on the areometer of Baumé. For this purpose, the resi-

dues of the sodas employed for the saponaceous emulsions are used. The cotton is known to be completely scoured when it sinks well, and when no hank comes floating up; it is then washed and dried.

To give cotton the first preparations, we prepare a soda ley at 1° in a great earthen jar, with about 150 kilogrammes of water. We try if it cuts the oil well, that is to say, if on pouring in a few drops of oil, it mixes well, growing milky, without leaving any little drops at the surface. In a jar of the above size, we mix 10 kilogrammes of oil with one-third of this ley, agitating carefully. Along with the second third, we mix from 12 to 13 kilogrammes of the liquor found in the stomach of ruminating animals. This mixture is to be poured into the jar where that of the oil was made, and after adding to it the last third of the ley, we stir again with great care. For passing the cottons through this saponaceous liquor, some of it is put into smaller jars, and after impregnating the cotton well with it, this is strongly wrung out. In proportion as we drain the jar, we agitate to prevent any separation taking place in the liquor.

The cotton passed through the oil remains piled up in a heap till next day, when it is taken to the tenter poles. As soon as it is dry, it is passed through a weak ley of soda, which has been mixed with the small residue of the soapy liquid; and it is in like manner left in a heap till it be carried next day to the drying. It is passed,

when dry, through a second ley a little stronger than the preceding.

The second soapy liquor is prepared with the same precautions as the first. There is employed for it the same quantity of ley, marking from 1° to 2°, and about 8 kilogrammes of oil, but no animal liquor is mixed with it. When the cotton is passed through this second oil, 20 kilogrammes of soda are added to the 15 kilogrammes previously used. The cotton is passed three or four times through the leys of this soda, taking the precaution of increasing each time the strength of the ley by half a degree, so that the last shall mark nearly 3° or 4° of Baumé.

In this operation potash may be substituted for soda. The cotton takes in fact a wine colour, but it loses this hue in the brightenings.

To prepare the cotton well for the galling and the aluming, it must be washed and dried. The galling bath is prepared, by boiling 10 kilogrammes of sorted galls in powder with about 100 kilogrammes of water, in which 15 kilogrammes of sumach have been previously boiled. After half an hour's boiling, 50 kilogrammes of cold water are poured into the copper, that the bath may be large enough for all the cotton to be passed through it. The cotton is dipped in as soon as the heat of the bath permits, and in the same manner as in the soapy liquor. It is then taken to the tenter poles.

The galling is one of the most delicate operations. It is of consequence to impregnate, wring

out, and dry the cotton very equally, as well as to dry it neither too slowly, nor in too moist an air, because the parts of the cotton that suffer the action of the air most, blacken, while the others remain of a white-grey. This produces inequalities.

As soon as the galling is dry, the cotton is alumed. With this view, 15 kilogrammes of reddish Levantine alum, or 12½ of Roman alum, are dissolved in 100 kilogrammes of water. Whenever the solution is completed, about 50 kilogrammes of cold water are poured into the copper, and as soon as the solution acquires a gentle warmth, much below that of the galls, the cottons are passed through it, and dried.

The alumed cotton should be thoroughly washed before proceeding to the other operations. Whenever it is well washed and dry, it is passed through one oil and three leys. The saponaceous liquor is prepared with 7 or 8 kilogrammes of oil, and the ley of the remainder of the sodas, which have served for the first preparations, which marks, as in the first, only from 1 to 2 degrees.

Fifteen kilogrammes of soda are now added to the jar, and the first ley is given at 3 degrees, raising each of the succeeding ones by half a degree, so that the strongest shall stand at from 4 to 5 degrees. After the third ley, it is washed and galled in a bath of 7½ kilogrammes of galls, without sumach. The aluming is made with 10 kilogrammes of Roman alum; after which it is power-

fully washed and dried. All these operations must be conducted with the same pains as the first.

In order to have a very uniform colour, two kilogrammes of madder must be employed for every kilogramme of cotton. With this madder half a kilogramme of sheep's blood is mixed for every kilogramme of cotton, and it is put into the bath whenever it is tepid. The cotton is turned in for an hour. When it has boiled for an equal time, it is withdrawn, and washed. It is now of a deep red, or bullock's blood colour. If the blood have not been intermingled, the colour is not so lively, nor so rich, although it be durable; and by substituting for it glue and other animal products, no such agreeable colour is obtained.

The colour of the cotton, after the maddering, is so dull and dark, that it could not be employed in this condition. It is cleared up, or lustre is given it by the *brightening*, and by solution of tin, which the workmen call the *secret*.

The brightening consists in boiling the cotton, for 6 or 7 hours, in the ley of 30 kilogrammes of soda, marking 2°, to which 8 or 9 kilogrammes of soap are added. The cotton is not put into the copper till the liquid be boiling hot. The copper is carefully covered, leaving but a small outlet for the steam, and the lid is strongly fastened down, that it may not be lifted up by the compressed vapour. The duration of the ebullition varies according to the intensity of the colour of the cotton, and the strength of the ley employed. When the cotton is thought to be sufficiently brightened,

the fire is stopped, the brightening (copper) is uncovered, and a hank is pulled out with an iron hook. If, after washing it well, the colour appears brilliant, and has not any black tint, or if some parts of the cotton begin to be impoverished, the copper is filled up with fresh water, and a stopcock is opened to run it off. Thus the cotton is washed, and is then left in the boiler till next day. It is now washed and dried.

In this condition, the cotton is of a fine colour; but it receives more lustre by the *secret*.

The solution of tin is prepared with pure nitric acid, marking 32°. 30 grammes of sal ammoniac are dissolved in the cold, in every half kilogramme of acid. When the solution is made, the tin is introduced in small rods, in the proportion of 30 grammes for half a kilogramme. It dissolves readily, and the liquor becomes opalescent. Tin is added even till this hue is perceived, which indicates that the acid can dissolve no more. 7½ kilogrammes of this solution are poured on a solution, somewhat tepid, of 3 kilogrammes of Roman alum, put into a large jar. In proportion as the solution of tin is poured into that of alum, the mixture grows turbid and white; at this time the cotton is passed through it with pressure, as usual. It is washed as it passes through.

The mixture of the two solutions should be capable of causing effervescence with calcareous earth, otherwise it will not brighten the colour properly. More or less solution of tin is employed, as the colour is to be more or less deep.

The lustre of the cotton may be further increased, by reviving it with an ebullition of 4 or 6 hours in a solution of from 8 to 10 kilogrammes of soap.

Linen yarn takes a colour almost as brilliant as that of cotton, but it must be passed through a double number of oils and leys. The latter must be even very strong, otherwise the oil flows out on the surface. The greatest attention must be bestowed on the scouring at first; for the yarn mingles and entangles by the heat, to such a degree that it can be neither dipped nor unravelled.

A very beautiful red is also obtained by limiting the galling and aluming to a single time, after the three oilings; and by observing to increase the doses of gall-nuts and alum a little.

By the following method we procure red colours, beautiful and permanent, without employing ley, oil, or galls.

Lime slaked in the air is to be dissolved in cold acetic acid. The solution marks from 5° to 6°; and it is reduced to 2° by the addition of water. Equal parts of this solution and acetate of alumina are mixed. The latter is prepared by pouring 5 kilogrammes of acetate of lead into a solution of 20 kilogrammes of alum for 175 kilogrammes of water. The above mixture is made tepid, and the cottons, merely scoured with care, are passed through it. They are dried, thoroughly washed, dried and maddered with 3-4ths of a kilogramme of madder for one kilogramme of cotton. They

are brightened with ley and soap, then passed through a solution of tin, and revived with soap alone, in the proportion of 12 kilogrammes of soap for 100 kilogrammes of cotton.

Very durable reds may be had by passing the cotton through this mordant, after having submitted it to oiling without galling. They are even very deep. But on passing the cotton which has received a single oil and four leys, through a mixture of acetate of alumina, with 1-4th, 1-12th, or 1-18th of lime, various very lively shades are obtained.

For making a dead red without lustre, termed in some places, burned red, or Indian red, on account of its resemblance to that of Indian handkerchiefs, the cotton is scoured, boiled for half an hour in lime water, passed through an oil mixed with some intestinal liquor, and through three leys. It is washed well and turned through a mordant composed of a tepid solution of 12½ kilogrammes of alum, to which 4 kilogrammes of acetate of lead have been added; and a moment afterwards, half a kilogramme of soda in powder, and 0.244 kilogrammes of sal ammoniac. It is washed with care, and maddered with its own weight of madder. If the colour be poor, it is passed once more through an oil, two leys, the same mordant, and a maddering. It may be brightened with soda and soap. The lime alone produces the difference between this colour and the preceding. It renders the colours more permanent, but duller.

The durable rose (colour) is produced by taking cotton passed through the oils, and which has received more numerous but weaker leys. It is galled with a ley of sumach (*lessive de sumac?*) in which 2½ kilogrammes of gall-nuts have been boiled; and alumed with 17½ kilogrammes of alum. It is now washed, dyed with madder of the best quality, the madder bath being whitened (*blanchi*) with two kilogrammes of the oxide of tin, that precipitates from the solution of this metal in nitric acid. It is brightened with weak ley and soap, dried, passed through a liquor formed of a solution of tin (in nitric acid at 32°, diluted with an equal volume of water), reduced to 4°. It is now washed and brightened in a solution of 15 kilogrammes of soap, till the colour be rosed in perfection.

On passing the cotton through soap of wool made with soda, taking the same pains as with the soapy liquor prepared for the red, and using very weak leys in the interval, then washing the cotton, and treating it by the same process as for dyeing wool scarlet, it assumes a scarlet tint, paler than that of wool, but pretty brilliant.

Cotton dyed red may, moreover, be made to pass through all the shades, down to the palest orange. For this purpose, pure nitric acid is diluted with 2-5ths (3-5ths ?) of water; chips of tin are oxidized in it till the liquor grows opal, and the solution is employed, at different strengths, from 2° to 20°. The colour varies according to the concentration of this solution. When it is

from 16° to 20°, shades are obtained which have some relation to those of scarlet.

In general, when brilliant colours are desired, we must not charge them too much with oil; we must give feeble leys long repeated, charge little with alum, employ the best madders, and, at last, brighten powerfully, without sparing the soap.

Chaptal * has expounded the principles on which are founded the multiplied operations of the Adrianople red dye, one of great importance in itself, and whose processes may have to a certain extent several useful applications.

He shews, that all these operations have for their object a triple combination; the first, that of the oil with the stuff; the second, that of the tannin with the former; the third, that of the alumina with the preceding two. To this triple combination there is lastly added, that of the colouring substance of the madder. Its dun portion is separated by the brightening, and the lustre of the red portion is increased by a judicious application of the solution of tin.

The oil must be brought into a disposition to combine with the stuff. For this purpose, solubility in water is communicated to it by means of soda; but the oil must be slightly retained by the alkali. Hence, merely a weak solution of soda should be employed, leaving the oil predominant, in order that the alkali may not seize it, and separate it from the stuff.

* Mémoires de l'Instit. vol. ii.

The oil, to be fit for combining with the stuff, must not be *a fine oil;* but it should have a tendency to form a solid combination; which is undoubtedly indicated, when it is said, *it should contain a strong portion of the extractive principle.*

Gall-nuts have an advantage over the other astringents, because the gallic acid, tending to combine with the alkali retained by the stuff, favours the more intimate combination of the oil with the stuff and the tannin.

Chaptal observes, on this occasion, that we may observe a combination of oil with tannin, on mixing a decoction of nut-galls with a solution of soap. It is of consequence to make this combination in due proportions; for if the astringent predominates it grows black; if it be in too small quantity, the colour becomes too weak.

When sulphate of iron, or acetate of alumina, is mixed with a decoction of gall-nuts, a greyish precipitate is formed; in like manner, galled cotton becomes grey the instant that it is plunged into an aluminous solution. Too hot a solution must be avoided, because a portion of the astringent is dissolved, which would impoverish the colour.

Haussman * employed, with success, solution of alumina in alkali. To obtain this solution, he precipitated the alumina of sulphate of alumina by caustic potash, of which he added such a quantity, that all the precipitate first formed was

* Annal. de Chim. tom. xli.

redissolved; to this solution he added 1-33d of linseed oil, which formed a liquor having the appearance of milk. As the oil separates with standing some time, the liquor must be agitated before using it. The hanks of cotton, as also those of linen yarn, should be successively steeped in it, evenly wrung out, and dried in the shade for 24 hours. After this they are washed, and the operation is renewed. Two impregnations are sufficient for obtaining a fine red, but by means of a third and a fourth, very brilliant colours may be produced.

The intensity of the red depends on the quantity of madder employed in the dye; with a weight equal to the hanks, the colour becomes rose by brightening; with four times the weight, the finest red is produced. The author prescribes the addition of carbonate of lime to the madder, always when the water made use of naturally contains none. Its effect is to decompose the sulphate of magnesia, which Bertholdi found in madder; provided the carbonate of lime can decompose the sulphate of magnesia, and if it be more advantageous to have sulphate of lime than sulphate of magnesia present.

He employs for the brightening, water alone, containing a small bag of bran, keeping up the ebullition for eight hours, and replacing what evaporates.

A great variety of different shades may be procured, by giving another colour to cotton before passing it through the oil bath.

Pallas relates, in the Journal of Petersburg for 1776, that the Armenians, whom the troubles of Persia obliged to retire to Astracan, dye Turkey red by impregnating cotton with fish oil, and drying it alternately during seven days; that they have remarked that the other oils would not succeed; that they did not take indifferently the oil of every fish, but chose that of certain fish, which becomes milky whenever an alkaline solution is mixed with it. After these repeated impregnations and desiccations, they wash the cotton, and dry it. They give it then an astringent bath, into which they put a little alum. They dye it in a bath of madder, with the addition of calf's blood. Lastly, they digest it for 24 hours in a solution of soda.

If cotton dyed with madder, by any process whatsoever, be boiled for some minutes in soap water, it assumes a rose colour. If it be then squeezed, a fat matter is expressed from it, which has the colour of Adrianople red, and which fixes itself on white cotton. Œtinger observed, in 1764,* that oil had the property of dissolving the colouring part of the Adrianople red, so that, if it be moistened with oil, its colour is communicable to white cotton when rubbed with it for some time. He thence concluded, that oil must enter into the preparation of the Adrianople

* Dissertatio de viribus radicis rubiæ tinctorum antiarchiticis a virtute ossa animalium vivorum tingendi non pendendibus.

red; and the Abbé Mazeas had proved long ago, that oil was indispensable to this dye.*

The species of madder employed has a great influence on the colour obtained. It appears indispensable, for procuring a colour equal to the Adrianople red, to employ the kind called *lizari*.

We should distinguish, in madder-dyed cotton, between the faculty of resisting, for a long time, the action of air, and that of resisting alkalies and soap. The last can be obtained only by means of oils and fats; but the first depends chiefly on the mordants that are used, and the other manipulations. Thus, the reds on printed stuffs may be very permanent, without supporting the action of leys, as the red of Adrianople does.

It is therefore right, independently of the beauty of the colour, to employ processes analogous to that of Adrianople, for such stuffs as are to be exposed to leying, and to frequent washing with soap. (NOTE FF.)

CHAPTER III.

Of Cochineal.

COCHINEAL was taken at first for a grain, but the observations of Lewenhoek shewed that it

* Recherches sur la cause physique de l'Adherence de la Couleur Rouge, &c. *Mem. des Savans Etrangers*, tom. iv.

was an insect. It is brought to us from Mexico. This insect lives there on different species of *opuntia*. The female has the body flattened on the side of the belly, and hemispherical on the back, which is marked with transverse wrinkles. Its skin is of a dull brown. Its mouth is an awl-shaped point, which issues from the cavity of the thorax. It has six very short brown feet, and no wings. The male has the body much elongated, of a deep red colour, covered with two wings, extending horizontally, and crossing a little on the back. It has two small antennæ at the head, and six feet, larger than those of the female. Its flight is not continuous, but it flutters about, hopping very rarely. Its life is only one month in duration, and ends with its amours. The fecundated female lives a month longer, dying after parturition. It is sometimes oviparous, and sometimes viviparous. After their birth, the young females disperse themselves on the joints of the opuntia, where they fix themselves by their proboscis till the end of their lives.

Two sorts of cochineal are gathered in Mexico. The wild cochineal, called by the Spanish name *grana silvestra*, and the fine cochineal, or *grana fina*, termed also *mèsteque*, from the name of a province of Mexico, and which is bred on the *nopal*. The first is smaller, and covered with a cottony down, which increases its weight with a matter useless in dyeing; it yields, therefore, in equal weight, less colour, and is of inferior price to that of the fine cochineal. But these disad-

vantages are perhaps compensated by its being reared more easily, and less expensively; and by the effects even of its down, which enables it better to resist rain and storms.

The wild cochineal, when it is bred on the nopal, loses in part the tenacity and quantity of its cotton, and acquires a size double of what it has on the other opuntias. It may therefore be hoped, that it will be improved by persevering care in the rearing of it, when it will approach more and more to fine cochineal.

Thieri de Menonville exposed himself to the greatest dangers in going to observe the breeding of the cochineal at Mexico, in order to carry away this precious production, and enrich the colony of St Domingo with it. He brought back with him some of the fine cochineal, of the wild cochineal, and of the nopals, which are the species of opuntia best adapted for nourishing these insects.

On his return, he occupied himself with the cultivation of the nopal, the different species of opuntia, and the rearing of the two cochineals; but death suddenly cut him off, and the fine cochineal soon perished. On his return he had observed the wild cochineal on a species of opuntia named *pereschia* or *patte de tortue*, which is found at St Domingo. This discovery did not remain unproductive. Bruley engaged with success in the rearing of this cochineal. The circle *des Philadelphes* employed themselves on it, and published a posthumous work of Thieri de Me-

nonville, in which very detailed instructions are given relative to the cultivation of the nopal, and the other opuntias which may be substituted for it with more or less success; as also the rearing of the cochineal, and its preparation.*

Two months after the mothers kept in reserve have been sown on the nopal, some young cochineals are seen to issue from them. This is the moment when the crop should be gathered. They are killed in boiling water. The plates of hot iron, and the stoves occasionally employed, may deteriorate the cochineals by too great a heat. After they are taken out of the water, they are carefully dried in open sunshine. They lose nearly two-thirds of their weight in the desiccation.

When the fine cochineal is dry, it is to be passed through a sieve large enough to let it go through, but capable of stopping the passage of the *bourres* (downs) and cotton of the larvæ of the males. The *bourres* (coarse downs) are put by themselves, and sold separately, or along with the wild cochineal.

The fine cochineal, when well dried and well preserved, should have a grey colour, bordering on purple. The grey is owing to the powder, which naturally covers it, and of which a little adheres. The purple shade arises from the co-

* Traité de la Culture du Nopal, et de l'Education de la Cochenille dans les Colonies Françaises de l'Amérique, précédé d'un Voyage à Guaxaca, par M. Thieri de Menonville. Ann. de Chim. tom. v.

lour extracted by the water in which they were killed.

Cochineal keeps for a long time in a dry place. Hellot says that he has tried some 130 years old, which produced the same effect as new cochineal.

It has been pretty generally believed, that cochineal owed its colour to the nopal on which it lives, the fruits of which are red. But Thieri de Menonville observes, that the juice which serves for its nourishment is greenish; and that it can live and breed on species of opuntia whose fruit is not red.

The decoction of cochineal is of a crimson hue, inclining to violet.

A small quantity of sulphuric acid caused this liquor to assume a red colour verging on yellow; and a little precipitate, of a fine red colour, was formed.

The solution of tartar changed the liquor to a yellowish-red. A slight pale red precipitate is slowly formed. The supernatant liquid remained yellow; on pouring into it a little alkali, it took a purple hue. The alkali quickly dissolved the small precipitate, and the solution was purple. Solution of tin formed a rose precipitate with the yellow liquor.

Solution of alum cleared up the colour of the infusion, giving it a redder tint. A crimson precipitate fell, and the supernatant liquid retained a crimson colour, slightly reddish.

The mixture of alum and tartar produced a brighter colour, more lively, inclining to yellowish-red. A much less abundant precipitate was formed, and much paler than in the preceding experiment.

The solution of tin formed a copious deposite, of a beautiful red. The supernatant liquid was clear, and did not change colour on the affusion of alkali.

Having poured in the solution of tartar, and afterwards the solution of tin, there was formed, more speedily than in the preceding experiment, a rose deposite, verging on lilac; and although a superabundance of the tin solution was added, the supernatant liquor remained a little yellow.

The solution of muriate of soda rendered the colour a little deeper, without making the liquor turbid.

Muriate of ammonia gave a shade of purple, without causing a precipitate.

Sulphate of soda produced no sensible change in the liquor.

Having boiled a little cochineal with half its weight of tartar, the liquor inclined more to the red, and had a much deeper colour than that proceeding from an equal quantity of cochineal without tartar; but the first yielded, with the solution of tin, a much more abundant precipitate, which had a more intense colour, so that the tartar promotes the solution of the colouring particles of the cochineal. Although the colour of

the solution be less deep, the precipitate derived from it by the solution of tin has a livelier hue.

Sulphate of iron formed a brown-violet precipitate, and the supernatant liquor remained clear, with a dead-leaf cast (*feuille morte*).

Sulphate of zinc caused a precipitate of a deep violet; the supernatant liquor remained clear and colourless.

Acetate of lead afforded a purple-violet precipitate, not so deep as the preceding; the supernatant liquor remained clear.

Sulphate of copper produced a violet deposite, which formed slowly; the supernatant liquor continued clear and violet.

If alcohol be digested on the extract which the decoction of cochineal yields by evaporation, the colouring particles dissolve, leaving a residuum, which retains merely a colour of wine lees, not removable by fresh alcohol. This portion affords, in the analysis by fire, the products of animal substances.

The alcoholic tincture of cochineal leaves, on evaporation, a transparent residuum of a deep red, which, when dry, has the appearance of a resin. It yields also, by distillation, the products of animal substances. Hence the colouring matter is an animal substance.

The cochineal *mèsteque* was compared to the wild cochineal of Mexico, and that reared in St Domingo, and transmitted by Bruley.

The decoction of the wild cochineal has the same hue as that of the cochineal of St Domingo.

This shade borders more on the crimson than that of the cochineal mèsteque; but the precipitates that are obtained, whether by solution of tin or of alum, are of a colour perfectly equal to those of the mèsteque cochineal; and it is these precipitates which colour stuffs by combining with them.

Oxygenated muriatic acid was had recourse to for determining the proportion of the colouring particles which the decoctions of the different cochineals contained. An equal weight of each of the three cochineals was boiled for an hour, rendering all the circumstances as equal as possible. These three decoctions being filtered, were poured each into a graduated glass cylinder, and some of the same oxygenated muriatic acid was mixed with them, till they were all brought to the same shade of yellow. The quantities of acid, which represent the proportions of the colouring parts, were found to be nearly in the ratios of the following numbers: eight for the cochineal of St Domingo; eleven for the wild cochineal of commerce; eighteen for the mèsteque cochineal.

We therefore perceive, that the cochineal of St Domingo is not only very inferior to the mèsteque cochineal, but to even the wild cochineal of Mexico; and in fact it is much more cottony, and smaller; but these disadvantages should not diminish the zeal of those who are engaged in rearing it.

The observations of Thieri de Menonville have already proved, that the wild cochineal lost its

cotton, and became larger by a succession of well nursed generations; and, at the beginning, nopals which had not attained the requisite size, were necessarily employed.

In reference to the quality of the colour, it has been seen that the cochineal of St Domingo did not yield to the mèsteque cochineal; but if the cotton with which it is covered should, in the operations on the great scale, injure the beauty of the scarlet, whose lustre is so easily affected, a more advantageous employment could be found for it, either for half scarlets, or for crimsons, and the other shades which are less delicate than that most lively of colours.

Wild cochineal is found in several parts of North America; Dr Garden observed it in South Carolina and Georgia. It exists also in Jamaica, and some might possibly be found equal to that of Mexico. Bancroft examined some of it that came from the Brazils, and obtained a colour equal in beauty to that of the mèsteque cochineal. It yielded half the quantity.

Anderson imagined, that he had found wild cochineal at Madras; but the hopes which he excited have not been realized. The insect which he mistook for the cochineal, seems, according to Bancroft, to approach to the kermes; and the trials which he made on a sample sent to him, shewed that this insect could give stuffs only a chocolate brown colour, but one indeed very durable.

A distinctive character may be observed between cochineal and madder, in their mode of

comporting themselves with reagents: both receive a yellow colour from the acids; but if the colouring particles of the cochineal be separated by a substance that precipitates them from the acid liquor, they reappear with their natural colour little changed; whereas those of madder retain a yellow or tawny hue. Hence the mordants which possess a redundant acid, such as the solution of tin, are employed much more successfully with cochineal than with madder. This effect is probably owing to the combination of the colouring part of the madder with the oxide of tin retaining a portion of acid, while that of the colouring part of cochineal retains none, or much less. (Note GG.)

Carmine is the lake obtained from cochineal, by means of alum; but with the cochineal is blended a certain proportion of *autour*, a bark which comes from the Levant, of a paler colour than cinnamon. *Chouan* is also commonly added. It is a yellowish-green seed of an unknown plant, which also comes from the Levant. It would seem that these two substances furnish, along with alum, a yellow precipitate, which serves to brighten up the colour of the cochineal lake in the same way as a yellow colouring matter serves to give scarlet a flame colour. A superior carmine is at present made by a process which is not promulgated. Carmine was formerly prepared with kermes, whence it takes its name. (Note HH.)

CHAPTER IV.

Of Dyeing Scarlet.

SCARLET is the most beautiful and the most brilliant colour among dyes. Taste fluctuates with regard to the shade in demand. Sometimes scarlet is sought for of a perfect and deeper red; more frequently inclining more or less to the colour of flame.

We cannot expect to obtain the desired shade from the precise doses prescribed in the processes, from variations in the quantity of the colouring particles contained in the different kinds of fine cochineal, and particularly from the solutions of tin that are used differing considerably from each other; but the just proportions of the ingredients to be employed may be readily determined by trials in the small way, so as to obtain the shade called for; and if the pieces which are dyed be above or below this shade, it is not difficult to find the suitable proportions.

The dyeing of scarlet is performed at two operations; the first is called the boiling *(bouillon)*, the second the *reddening*.

For a boiling intended to dye fifty kilogrammes (about one cwt.) of cloth, three kilogrammes of tartar are thrown into water, a little more than lukewarm. The bath is strongly raked up, and when it is a little hotter, 1-4th kilogramme of cochineal in powder is thrown in, and very well mixed.

An instant afterwards, 2½ kilogrammes of a very clear solution of tin are poured in, which are carefully mingled; and whenever the bath begins to boil, the cloth is introduced, and made to circulate rapidly round for two or three turns; the motion is then slackened. After two hours of ebullition, it is lifted, aired, and carried to the river to be well washed.

For preparing the second bath, which is the *reddening*, the boiler is emptied. When this bath of water is about to boil, 2¾ kilogrammes of powdered and sifted cochineal are put into it. This is mixed with care, and the stirring being over, when the crust, which spontaneously forms on its surface, opens of itself in several places, about 7 kilogrammes of solution of tin are poured in. If, after this, the bath rises above the edge of the boiler, it is refreshed (cooled down) by putting in some cold water.

When the solution is well mixed through the bath, the cloth is thrown in, with the precaution of whirling it rapidly for the first two or three turns. It is boiled for an hour, pressing it down into the bath with rods whenever the agitation raises it up. It is now taken out, aired, cooled, then washed in the river, and dried.

The proportions of cochineal and solution of tin which enter either into the *bouillon* or *reddening*, are not uniform. There are dyers who, from Hellot's account, succeed very well by putting two-thirds of the composition and one-fourth of the cochineal in the *bouillon*, and the other

third of the composition and the three-fourths of the cochineal into the *reddening*. Hellot asserts also, that it is not injurious to employ tartar in the reddening, provided no more of it be used than one-half the weight of the cochineal; and it appeared to him to render the colour even more durable. This is actually the practice of some dyers. It has been seen to promote the solution of the colouring particles, an effect which particularly takes place when it is ground along with the cochineal; and by this means the residuum is found to be better exhausted. This consideration has less weight when the work is consecutive, because then the colouring particles present in the residuum are employed in the subsequent operations; but it is proper not to neglect the influence of the tartar on the quality of the colour, which we shall determine more particularly.

There are some dyers who do not lift the cloth out of the *bouillon*, but only refresh this, in order to make the *reddening* in the same bath, by pouring in the infusion of the cochineal prepared by itself, and to which they have added the proper quantity of the composition. Time and fuel are thereby saved, and a good scarlet may be obtained.

As it is usually desired that the scarlet should have much vivacity, approaching to a flame colour, a yellowish tint is given it, by boiling fustet in the first bath, or indeed by adding a little curcuma to the cochineal. The employment of these ingredients may be discovered on cutting the

scarlet cloth, its interior being in this case dyed yellow; for, by the ordinary process, the cochineal does not penetrate into the inside of the scarlet, but leaves it white, when it is said to cut.

In the scarlet dye, it is of advantage to use a boiler of tin, because the acid employed attacks copper, whose solution might injure the beauty of the colour. However, as these boilers are difficult to make of a certain size, and as they are liable to be melted, if the fire be not withdrawn before they are emptied, several dyers use copper boilers. But care must be taken to keep them very clean, not to let the acid liquor remain in them, and to prevent the cloth touching the metal, either by means of a network, or an open wicker-work basket.

Scheffer prescribes for the *bouillon*, one part of solution of tin for ten parts by weight of cloth, with an equal quantity of starch and of tartar as of solution. He remarks, that the starch tends to make the colour more uniform, and he recommends to throw into the water, when it boils, 1-128th of cochineal; to agitate well; to let the wool boil in it for an hour, and then to wash it. He prescribes next, the boiling for half an hour in the bath, which serves for the *reddening*, with 1-32d of starch, 1-24th of solution of tin, 1-32d of tartar, and 1-18th of cochineal.

It appears, that Scheffer employs a much smaller quantity of solution of tin than Hellot; but what he does employ contains much more tin.

Poerner describes three principal processes, according as the shade is to be more or less deep, or more or less of an orange hue, which he wishes to give to the scarlet. He varies the proportions of the solution of tin, of cochineal, and tartar, or omits the last ingredient.

For conducting the process of the scarlet dye in the most beneficial manner, and for varying its results, according to the end in view, the effect of each of the ingredients employed in it must be ascertained.

In the first edition of these elements, the property of giving a deeper and more rosy hue to the colouring particles of the cochineal had been attributed to the tartar. This opinion might be regarded even as the general one; but Bancroft has justly called it in question. He states, that if the tartar be left out, the colour is a crimson; that the tartar gives rise to an insoluble tartrate of tin, which forms with cochineal a yellow colour; that the ordinary scarlet is a mixture of one-fourth of this yellow colour, and three-fourths, or a little more, of the crimson colour, which cochineal gives with the solution of tin. Consequently, he proposes to substitute for the tartar, a preliminary dye with quercitron, which, by its yellow, produces the same effect, and to dye afterwards with solution of tin and cochineal, of which, in this case, no more than four-fifths of the ordinary proportion are required.

We have dyed scarlet, by employing the proportions of solutions of tin and tartar which have

been pointed out, in the first place; in another pattern, we doubled the proportions of tartar; and in a third, we left out this ingredient. The first took a beautiful scarlet colour; the second inclined more to yellow; and the third had a vinous colour, and was less lively, although not exactly crimson.

It is true, therefore, that the tartar causes the colour of cochineal to incline to yellow, and that it produces more of this effect, the greater its proportion. We have not determined, whether this effect may be entirely supplied by a yellow produced by other means. If the proportion of the solution of tin is too great, it becomes prejudicial, and impoverishes the colour, because a portion of the colouring matter is retained in solution. But the different proportions of tin which this solution contains have also some influence. It has appeared to us, in general, that the larger the proportion of tin, the deeper was the colour. We have been sufficiently diffuse on the preparation of the solution of tin, *Part First, Section Fifth.*

Bancroft recommends a solution of one part of tin, made in a mixture of a little more than two parts of sulphuric acid, and of three of muriatic. He relates several other attempts which he has made, both by dissolving tin in different acids, and by substituting other salts of an earthy or metallic base for the solution of tin. But these attempts do not point out applications sufficiently useful to the art for us to detail their results.

Experience shews, that scarlet may be dyed by a single operation; but an uniform dye is better ensured by dividing it into two operations, when the dyeing is on the large scale. This is not the case with the lighter shades.

If the scarlet just dyed be too much of an orange cast, this may be weakened by washing it in hot water, especially if the water contains some salt with an earthy base.

The *reddening* (bath), which has served for dyeing the scarlet, is not exhausted of its colouring particles, but contains still a quantity, which varies in proportion as the cochineal has been reduced to a powder of greater or less fineness, and according to the length of the ebullition which it has suffered. This bath contains, moreover, a portion of the mordants put into it; but as the nature of this residuum is not uniform, it would be illusory to prescribe the precise doses of the ingredients that should be added for obtaining the shades that may be sought from it. Practice in the same process, and experience, easily guide an intelligent dyer. We shall therefore confine ourselves to some general considerations.

If much cloth is to be dyed scarlet, we may use for the *bouillon* a *reddening* which has been just employed for dyeing, subtracting from the ordinary quantity of cochineal what may be supposed to remain in the bath, and diminishing likewise the amount of solution of tin. But if a flame colour be wanted, we should begin

by boiling a bag of fustet, withdrawing it before we add the other ingredients.

This bath may then be used, as soon as the cloth is taken out, for making pomegranate colour, by boiling a bag of fustet in it. That (the fustet) which has already passed through a bath, is fitter for this shade than what is fresh. After withdrawing it, some tartar and composition are thrown into the bath. It is to be well stirred with the rake, and the cloth must be treated as for the scarlet dye.

In the sequel of this colour the bath may serve for capuchin colours *(les capucines)*, by boiling fustet in it, with the addition of tartar, and solution of tin.

The preceding *bouillon* may likewise be used for the *langouste*, orange, *cassis*, golden, and jonquille colours, by boiling fustet in it, adding a little cochineal, and more or less solution of tin and tartar.

When the *bouillon* has been given to all the cloths that are to be dyed, proceeding from the deepest to the lightest colour, they are passed through the *reddening*, advancing, contrarywise, from the lightest to the deepest colour, adding always more and more cochineal and solution of tin, till the pomegranate and flame colours be attained. When it is come to the turn of the golden and jonquille hues, fustet is added, unless these colours have been finished in the first bath, as we shall see may be done for certain shades.

For gold colour and *cassis*, a little madder is added.

The colours of gold, *cassis*, jonquille, and chamois, may be made after the scarlet *bouillon*, by adding for the first two, fustet, solution of tin, and a little madder; and a little more fustet, and a little less solution of tin, for the gold colour than for the *cassis*. Much less solution of tin is needed for the chamois (buff). Hind colour *(couleur de biche)* may be made in the sequel of a scarlet *bouillon* without any addition. The coffee with milk colour (*café au lait*) requires a little fustet and solution of tin, with a very small quantity of madder. To the last ingredients, a little cochineal and tartar are added for the chocolate with milk colour.

A fresh bath is usually had recourse to for the *bouillon* of the cherry colours; and it is composed of tartar and solution of tin. For dyeing them, thereafter, a *reddening* is employed which has served for scarlet, adding to it tartar, solution of tin, and a little cochineal. For the *bouillon* and the *reddening* only half the time is taken that are employed in these operations for the scarlet dye; and, in general, the time is shortened in proportion to the delicacy of the shades. For the *bouillon* of rose, the cherry *reddening* may be used; and *its* reddening is composed of a small quantity of solution of tin, tartar, and very little cochineal. The colour may be deepened, by passing the cloth through hot water on its coming out of the bath.

Flesh colour is made in the sequel of a *reddening*, by throwing away a little of the bath, and refreshing it with cold water. It may likewise be made in the sequel of the violets, by adding a little solution of tin. The boiling must continue but a very short time.

Lastly, the *reddening* from which the scarlet cloth has been withdrawn may serve for the greys that are to have a vinous cast, by refreshing the bath, adding to it gall-nuts, and then a little sulphate of iron, or green vitriol.

It must be observed, that the weak and delicate shades, such as the *langoustes* and the oranges, as well as the lilacs, mallows, cherries, roses, have more lustre and freshness when they are prepared in a single bath, than when they are subjected to both the *bouillon* and the *reddening*. On this account it is sufficient to introduce into this bath the necessary ingredients. The cloth, when merely moistened, and unimpregnated with mordant, becomes charged with the colouring particles less readily, but in a more evenly manner. There is also in this mode of operating a saving of time and fuel.

CHAPTER V.

Of the Crimson Dye.

All the processes employed for obtaining the different shades of crimson, from the lightest to

the deepest, may be referred to two. The desired crimson hue is given either to cloth already dyed scarlet, or the crimson is given at first.

Alum, the salts in general with earthy base, the fixed alkalies and the volatile, possess the property of changing the colour of scarlet into crimson, which is the natural colour of cochineal. The cloth dyed scarlet has only to be boiled, therefore, during about an hour, in a solution more or less charged with alum, according as a deeper or lighter crimson is wanted; but as the other salts with earthy base have the same property, and as common waters contain more or less of these salts, it happens that they rose to a greater or smaller degree the scarlet shades passed through them, especially when they are heated. The quantity of alum necessary to obtain the crimson varies according to the nature of the waters employed; and when they are well charged with these salts, they may even suffice without the addition of alum. When a piece of scarlet has any defects, it is set apart for crimson.

Hellot says that he has tried soap, soda, potash, and the *cendres gravelées* (crude potash); that all these substances produced the crimson wanted, but that they deadened it, or gave it less lustre than alum. Ammonia, on the contrary, produces a very good effect; but as it evaporated speedily, a considerable quantity of it had to be put into the bath, which increased the price of the dye. He therefore thought of putting into the bath, somewhat more than tepid, a little muriate of am-

monia, or sal ammoniac, and an equal quantity of common potash. The cloth assumed immediately a very rosy and very brilliant colour. He even thinks, that by this means, which heightens the colour, the quantity of the cochineal may be somewhat diminished. Poerner, who gives this very process, prescribes the leaving the scarlet for 24 hours in the cold solution of the ammoniacal muriate and potash.

To dye crimson directly, a solution of 0.153 k. of alum, and 0.092 of tartar, with 0.060 of cochineal, are made use of in the *bouillon* for every kilogramme of cloth; but solution of tin is commonly added, although in smaller proportion than for scarlet. The processes that are pursued vary much, according to the depth of the shade desired, or as it is more or less removed from the colour of scarlet. Some persons make use of the muriate of soda for the *bouillon.*

Archil and potash are often employed to brown crimsons, and give them more lustre; but this showy lustre *(bloom)* soon vanishes.

The *bouillon* for the crimson is made sometimes in the sequel of the *reddening* bath of scarlet, by adding to it tartar and alum; and it is asserted, that even the *soupe au vin*, (literally, wine-soup colour), of which both the *bouillon* and the *reddening* are made in the sequel of scarlet, has more lustre than when it is formed from a fresh bath. For these colours, the wild cochineal may be substituted for the fine; but as it contains fewer

colouring particles, its quantity must be augmented.

The *reddening* which has served for crimson may be employed for purples, and other compound colours, of which we shall treat hereafter.

Half scarlets and half crimsons, (half grain scarlets), are made by replacing the half of the cochineal with madder, giving, moreover, the same *bouillon* as for scarlet, and following, as to the rest, the process of the *reddening* of scarlet or crimson. Instead of a half, other proportions of madder may be employed, according to the effect wanted. More lustre is also given to the ordinary madder red, by forming its *bouillon* in the sequel of the *reddening* of scarlet.

On silk, the fine crimson due to cochineal is distinguished from the false crimson obtained from brazil wood.

Silks intended to be dyed cochineal crimson, should be boiled only at the rate of 20 parts of soap for 100 of silk, because the slightest yellow cast which remains on the silk, when it is scoured only to this degree, is favourable to this colour.

Silks well cleansed in the river, are put into an aluming of the greatest possible strength; there they are usually left from the evening till next morning, after which they are washed and subjected to two beetlings in the river.

For preparing the bath, an oblong boiler is filled with water, to about one-half or two-thirds; and when this water boils, pounded white nut-galls are thrown in to about a 6th or an 8th of the weight

of the silk; and after boiling a few seconds, there is put into the bath bruised and sifted cochineal, from an eighth to a fifth for each quantity of silk, according to the shade that is wanted. To the bath is afterwards added a sixteenth of tartar for one part of cochineal, and, when the tartar is dissolved, as much solution of tin. This solution should contain much more tin than that made use of for scarlet, otherwise the colour would be too bright. Macquer directs it to be made with sixteen parts of nitric acid, two of ammoniacal muriate, as much fine grain tin, and twelve of water.

The ingredients are mingled, and the boiler is filled up with cold water; the proportion of the bath being about eighteen or twenty litres of water for each kilogramme of silk. The silks are immediately plunged, turning them round the skein sticks till they appear very uniform. The fire is then increased, and the bath is kept boiling for two hours, turning round the silks from time to time; after which the fire is withdrawn, and the silks are plunged into the bath. Here they are kept for some hours. They are then washed in the river, giving them two beetlings, when they are wrung and dried.

If it be wished to brown the crimsons, they are passed, after washing them, through a solution more or less charged with sulphate of iron, according to the shade wanted. If the silk is to retain a shade of yellow, more or less of the decoction of the fustet wood is added to this solution.

White gall-nuts are preferable, because black ones deaden the colour of crimson; and if even too large a quantity of the former be introduced, the colour becomes duller. Macquer says, that the galls serve merely to increase the weight of the silk; their general effect, however, is to render the colours more durable. They are indispensable, at least for the crimsons intended to be browned (saddened).

The test of vinegar, often used for distinguishing the cochineal crimson from the spurious, is deceitful, because it cannot distinguish the colours obtained from (brazil) wood, when they are fixed by means of the solution of tin; for in this case they resist vinegar as well as those made with cochineal.

Macquer gives the description of the crimson silk dye of Damascus and Diarbekir, which was communicated by Granger; as also of the process followed at Genoa.

We have seen that a very small quantity of solution of tin was put into the bath for dyeing silk crimson. Were it wished to employ the same process by which wool is dyed scarlet, the silk would lose its lustre (bloom), and acquire but a faint colour; but Macquer and Scheffer have both published a process, differing only in some circumstances, for dyeing silk rose and *ponceau*, by means of solution of tin, employed cold, in order to avoid its too lively action on the silk.

In the process which Macquer published in 1768, the solution of tin is prepared by throwing

three parts of tin very gradually into a mixture of four parts of nitric acid and two of muriatic. When the solution is finished, six parts of silk are introduced, which has had previously a bath of annotto; there it is left for half an hour, when it is wrung out and washed, till the water ceases to be foul. For dyeing one pound of silk, 1-4th of cochineal, with 1-16th of tartar, is employed. The liquor is made to boil; it is diluted with cold water, so that the hand can bear its heat: into this the silk is immersed, the fire is raised, and after a minute's ebullition it is taken out and washed. The silk receives, by this process, an augmentation of weight amounting to a fourth; its colour resists soap, and is much more durable than that given by carthamus (safflower).

In 1751, Scheffer published in Swedish the following process. One part of tin is dissolved in four parts of nitric acid, and one of muriate of soda; and the solution is diluted with a double quantity of water. In this the silk is left to macerate for 24 hours; when, it is taken out and washed in clear water, till this is no longer milky. The silk is then dyed, by boiling it for a quarter of an hour with 5-6ths of its weight of cochineal, in a bath not much diluted: the remaining liquor contains still a good deal of colouring matter, which may serve to dye silk of a lighter shade, or indeed to dye it crimson by the ordinary process; it may serve likewise for wool.

Scheffer describes some variations of his process for obtaining different shades, of which we shall now recapitulate the principal. On wringing silk out of the solution of tin, letting it lie all night in a cold solution of one part of alum to thirty-two of water, wringing it in order that it may be dried, washing it, and then passing it through a bath of cochineal, it takes merely a pale *ponceau* (poppy) colour. If after diluting one part of solution of tin with eight parts of water, the silk be set to macerate in it for 12 hours,—be afterwards kept all the night in the solution of alum,—be then washed, dried, and passed through two baths of cochineal as above, adding to the second bath a little sulphuric acid, a beautiful *ponceau* will be obtained.

The chief difference between the processes of Macquer and Scheffer, consists in the yellow ground which Macquer gives the silk. Scheffer employs a larger proportion of cochineal in the dyeing bath; but, from the report of the very persons who co-operated at Macquer's experiments in the manufactory of the Gobelins, it must be acknowledged, that the silk dyed by his process had never reached the scarlet hue. This colour, so much desired, has, however, induced dyers to multiply their attempts. Those who appear to have approached nearest to their object, begin with dyeing the silk crimson; they then cover this dye with that of carthamus, by the process hereafter described; and they give it finally a yellow dye in the cold. Thereby a beautiful

colour is obtained. But the carthamus dye is destroyed by the action of the air, and the colour grows pretty speedily brown.

Cochineal is little used for dyeing cotton and linen, because a beautiful and permanent red can be given them by means of madder. Scheffer, however, describes a process which may be tried. The linen or cotton is steeped for 24 hours in a cold solution of tin; after which it is wrung, washed, and made to boil for a quarter of an hour with 4-6ths its weight of cochineal. The cotton takes a light red. These colours bear the action of the sun, but not of soap. Berkenhout also gave, in England, a process, which, by Bancroft's description, differs little from that which we have given for silk; but it is said to produce merely a crimson, because there is no yellow in it.

The difference between the processes to which recourse must be had for giving silk and cotton the colour of scarlet, appears to depend on these substances having a much smaller disposition to unite with the colouring matter of cochineal, or with the combination of this colouring matter and tin; whence it results, that this combination separates, reunites in too considerable masses, and precipitates before its union can be effected with the stuff. But this inconvenience is obviated by first impregnating the stuff with solution of tin, because the oxide of tin being combined with it, the colouring molecules of the cochineal come and fix themselves in it, in which case this compound can no more be precipitated. It therefore

appears to us, that, in order to succeed in this process, our views must be directed towards the fittest means for producing, at first, a combination of the oxide of tin with the stuff, without altering the latter; and then to give it a due alloy of the red of cochineal, and of yellow, either by means of tartar or by the admixture of a yellow colour.

CHAPTER VI.

Of Kermes.

THE kermes (*coccus ilicis, Linn.*) is an insect, found in several parts of Asia and the South of Europe. It was known to the ancients by the name of *coccum squarlatinum, coccus baficus, infectorius, granum tinctorium.* That collected in Galatia and Armenia was preferred. At the present day, it is gathered chiefly in Languedoc, Spain, and Portugal.

The kermes lives on a small oak (*quercus coccifera, Linn.*) The females grow big (*massives*), and finally remain motionless, when they have nearly the form and size of a pea, and are of a reddish-brown colour. Their shape caused them to be long mistaken for the seeds of the tree on which they live; whence they were called grains of kermes. They have been also called vermilion.

The first person who spoke of them with tolerable accuracy, was Pierre de Quiqueran, bishop of Sénez, in 1550, *de laudibus provinciæ.*

The history of this insect is found in a memoir of Nissole, *Acad. des Sciences*, 1714; and particularly in Reaumur's *Mémoires pour servir à l'Histoire des Insectes*, tom. iv.

It is thought that the kermes takes its name from an Arabic word, which signifies a little worm, *vermiculus*, from which comes the name vermilion also given it. Astruc derives the term from two Celtic words, of which one signifies oak, and the other acorn (*gland*): *Mémoire pour servir à l'Histoire Naturelle de Languedoc.*

The kermes is fixed to the bark of the shrub by a white cottony down, furnished by the insect. Chaptal has observed that this down, as well as that which all the insects of this kind afford, has several of the characters of caoutchouc; that it was insoluble in alcohol, that it melted at the heat of boiling water, and burned with flame on red-hot cinders. To him we owe the following description of the method pursued in Languedoc, to make the harvest of kermes.

"Towards the middle of the month of May, they begin to gather the kermes, which has then acquired its ordinary size; it resembles in its colour and form a little sloe. This harvest usually lasts till the middle of the month of June, and sometimes longer, if the great heats be retarded, or if violent rains do not come on; for one storm of rain is sufficient to put an end to the crop for a year. Women are commonly employed in this harvest. They go out early in the morning with a lantern in their hands, and a

glazed earthen pot, and thus proceed before day-break to detach the kermes from the branches with their fingers. This time is the most favourable; 1*st*, because the leaves which are furnished with prickles give then less annoyance, being softened by the morning dew; 2*d*, because the kermes weighs more, either from its not being dried by the sun, or from fewer young ones making their escape, which are hatched by the heat. Persons are, however, to be seen sufficiently intrepid to gather it during the day-time; but this is rare.

"One individual can gather from one to two pounds in a day.

"In the first season of the harvest, the kermes weighs more; hence it sells for less than towards the conclusion, when it is drier and lighter.

"The price of fresh kermes varies, moreover, according to the demand of purchasers and its scarceness. It commonly fetches from 15 to 20 sous (halfpennies) per pound at the commencement, and from 30 to 40 towards the conclusion of the harvest.

"Those who purchase it are obliged as soon as possible to put a stop to the development of the eggs, so as to prevent the escape of the young contained in the *coque*. This *coque* (shell) is merely the body of the mother, which has enlarged by the formation of the eggs. The female has no wings. It fixes and takes up its abode on a leaf. The male comes to impregnate her, and she then enlarges merely by the development of

the eggs. In order to kill the young contained in the eggs, the kermes is steeped in vinegar for 10 or 12 hours, or it is exposed to the fumes of vinegar, which takes less time, for half an hour is enough. It is then dried on cloths. This operation gives it a wine-red colour."

When the living insect is crushed, it affords a red colour. It has a pretty agreeable smell, and a taste somewhat bitter, harsh, and pungent; when dry it communicates the same odour and taste to water and alcohol, which thereby acquire a deep red colour. The extract procured from its infusion retains this colour. (NOTE II.)

To dye spun worsted with kermes, it is first boiled in water along with bran for half an hour; next for two hours in a fresh bath, with a fifth of its weight of Roman alum, and a tenth of tartar. *Sour* water is usually added to it. It is taken out after this ebullition and enclosed in a bag, which is carried to a cool place, and left there for some days. To form a saturated colour, there is put into a tepid bath three-fourths of kermes, or even a weight equal to that of the wool introduced into the bath at the first *bouillon*. As the density of cloth is more considerable than of spun worsted or wool in the fleece, it requires a fourth less salts in the *bouillon*, and of *kermes* in the bath. With smaller proportions of kermes, lighter and paler colours are obtained. When a series of shades is to be made, it is necessary to begin, as usual, with the deepest.

Hellot directs us to throw into the boiler containing the kermes a small handful of the refuse wool, (or cot), before immersing what is to be dyed in it, and to let it boil there for an instant. It removes a species of black fecula, and the wool dipped afterwards assumes a finer colour.

Before carrying the newly dyed wool to the river, it may be passed through a water bath slightly tepid, in which a small quantity of soap has been dissolved. The colour thus takes some lustre, but it is a little rosed, that is to say, it gets a cast bordering on crimson.

By employing kermes with tartar, without alum, and as much solution of tin as for cochineal scarlet, Hellot has procured from a single bath an extremely lively cinnamon. The cloth having been macerated in a solution of sulphate of potash, it took with the kermes an agate-grey colour of considerable beauty and solidity; after maceration with sulphate of soda, a dirty grey of little permanence; with sulphate of iron and tartar, a fine grey; with tartar and sulphate of copper, an olive colour, and the same with nitrate of copper. The solution of bismuth, poured drop by drop into the kermes bath, produced a violet. All the acids turn it into a cinnamon bordering more or less on red, according as the acids are weaker, or in smaller quantity. The alkalies rose the colour, and render it dull.

The red colour which kermes communicates to wool, has much less lustre than the scarlet made with cochineal, which came to be preferred

as soon as the art of heightening the peculiar colour of cochineal by means of the solution of tin became known; but the former has much more permanence, and spots of grease can be effaced from it without its colour being affected. It is the blood-red, preserved without alteration in the old tapestries. To the scarlet of kermes, the name of *grain scarlet* was given, because this insect was mistaken for a seed (*graine*). They gave it likewise the name of *scarlet of Venice*, because its principal manufactory was in that city.

The solution of tin was not omitted to be employed for kermes, as well as for cochineal; and Scheffer describes several processes for dyeing by this method with kermes; but its colour then verges on yellow or cinnamon, because the combination formed with the colouring matter and oxide of tin retains from the impression of the acid a yellow colour, as happens to the colouring matter of madder.

The durability of the colour of kermes has often excited a regret that our dyers should have abandoned its use, for they employ very little of it at present. Some mixed a small quantity of it with the cochineal. It is observed, that this mixture contributed to give body to the colour, but it dimmed its lustre. The greater part of the kermes comes from the Levant.

Only a dull reddish colour has been hitherto given to silk, by means of kermes.

The scarlet, for which one-half of kermes and one-half madder are employed, is called *half grain.* This mixture gives a very permanent colour, but not lively, bordering a little on blood colour. It is said that the turbans fabricated for the Levant, are dyed in this way at Orleans. A little brazil wood is probably added.

The *coccus polonicus* is a small round insect, found adhering to the roots of a species of *polygonum* (*sclerantus perennis*). It is collected towards the end of June, in some provinces of Poland. It appears to have properties similar to those of the kermes; but no use is made of it in Europe. It is sold to the Turkish and Armenian merchants. It is used in Turkey for dyeing wool, silk, and horse-hair; and women employ it for dyeing their nails.

There are several other insects which might equally afford a red colour; some even have been employed; but the advantages presented by cochineal have made their use be abandoned or neglected.

CHAPTER VII.

Of Lac, or Gum Lac.

Lac is a substance of a more or less deep red colour, which is brought to us from India, under different forms. This substance is a production analogous to that of bee-hives, constructed by a

species of *coccus*, which Kerr and Roxburgh have described.* It lives, and forms cells, on different species of shrubs. Geoffroy, who has given some interesting observations concerning this substance,† regards it as a true wax, which owes its colour only to the embryos of insects that have formed *alveoli* (little holes) in it of a nearly round form; hence the name of gum is improper.

Several species of lac are distinguished, the principal being, 1. Stick lac, the production which the ants have constructed round small branches. This species is the richest in colour, though there is some of it in Madagascar nearly colourless.

2. Grain, or seed lac. It is less coloured than the preceding.

3. Lac in tables (shell lac). It is imported in small plates of variable size and transparency. It has usually a dirty colour, and is mixed with some wood and earth. It would seem that the Indians have already extracted the colouring matter from it. These two latter kinds are employed for sealing wax; colouring them with minium (or vermilion) for red wax; with lampblack for black wax; with orpiment for the wax of an aventurine colour, &c. Geoffroy says, that the lac, separated from the small bodies that it contains, afforded him, on distillation, the same products as wax; and that the small bodies,

* Philos. Trans. 1781, 1791.

† Mém. de l'Academie, 1714.

which may be ground into a fine red powder, afforded him the products of animal substances. The colouring particles, which are owing to these small bodies, which he takes for chrysalids, dissolve in water and alcohol, giving these liquids a fine red colour. (NOTE KK.)

For dyeing, stick lac must be chosen of the deepest colour. It is freed from the twigs, and reduced to powder.

The colour obtained from lac has not the lustre of the scarlet made with cochineal, but it has the advantage of possessing more permanence. It may be used profitably by mixing a certain quantity of it with cochineal; and if too great a proportion be not taken, the scarlet is no less beautiful, and it is more durable.

In order to separate the portion soluble in water, and to estimate its proportion to the wax or resin, Hellot was accustomed to extract it by means of water and mucilage of comfrey, to throw down its colouring matter with alum, to collect and dry it. He obtained, by this process, a precipitate which formed one-fifth of the weight of the lac, and it was this precipitate which he used for dyeing. But this precipitate is a combination of the colouring particles with alumina, or the base of alum.

Lac may be employed in a simpler manner: the only precaution is to boil the cochineal and the solution of tin for the proper time; after which the bath is refreshed, and the lac in pow-

der is introduced. It requires a very moderate heat, otherwise it dyes in an unevenly manner, and also a still more considerable quantity of the tin solution than cochineal. The cloth should be washed very hot on coming out of the boiler, because the resinous particles attached to it are difficult to separate when cold. Lac may be employed with success for the *soupe au vin* colour, by putting it in the *bouillon;* into which, in this case, no alum must enter, because it would precipitate the colouring matter too rapidly. Cochineal is used in the *reddening* bath, and it is saddened in the ordinary way.

According to Hellot, fixed alkali, or lime water, changes the lively red produced by lac into a wine-lees colour; and sal-ammoniac affords cinnamon, or bright chesnut colours, according as there is more or less salt.

Geoffroy conjectures, that lac is used for dyeing red morocco leather in the Levant, after being subjected to suitable preparations. In fact, lac appears to be employed along with cochineal for this purpose at Diarbekir; and at Nicosie kermes is used. Quemiset says, that kermes, cochineal, or lac, may be employed indifferently.*

An advantageous distinction of lac over kermes appears to be, its bearing the action of solution of tin, and experiencing its good effects, without having its colour changed to yellow; and we

* L'Art d'Apprêter et de Teindre toutes sortes de Peaux.

have seen, that it requires even a larger proportion of it than cochineal does.

CHAPTER VIII.

Of Archil.

The archil used in dyeing, is in the form of a violet-red paste. Two kinds of it are chiefly distinguished, the archil plant of the Canaries, and the ground archil (*de terre*), or that of Auvergne, called also *pérelle*. The first is by far the most esteemed. It is prepared from a species of lichen (*lichen roccella*) which grows on rocks adjoining the sea, in the Canary and Cape de Verd Islands. The second species is prepared from a lichen (*lichen parellus*) which grows on the rocks of Auvergne.

Micheli, as quoted by Hellot, says, that the workmen who prepare the archil at Florence, reduce the plant to a fine powder, which they pass through a sieve; that they then sprinkle it gently with stale urine; that they stir the mixture once a-day, adding to it each time a certain proportion of soda in powder, till the materials have assumed a columbine (dove) colour. The substance is now put into a wooden cask, and urine is added to it, or lime water, or solution of gypsum, till its surface be covered, in which state it is preserved. In a description to be found in the work of

Plictho, sal ammoniac, sal gem, and saltpetre are added to this preparation; but Hellot convinced himself by experiments, that lime and urine were the sole ingredients necessary; and that it was requisite to stir up the mixture frequently, adding at the same time new doses of lime and urine. It is proper to let the volatile alkali, which is formed, evaporate at the end of the process, in order that the archil may assume the odour of violets, which characterizes the well-prepared article. To preserve it long, however, it must be kept moistened with urine.

Kalm says, in an appendix to a Memoir of Linnæus, in the Stockholm Transactions for 1745, that in some parts of Sweden two lichens, which he describes, are used for dyeing red. In the same Transactions for 1744, there is said to be found, likewise in Sweden, a species of lichen (*lichen foliaceus umbilicatus subtus lacunosus, Linn. Flor. Suec.*), which, being prepared with urine, dyes wool and silk of a beautiful and permanent red or violet.

There are several other species of moss and lichen which might be employed in dyeing, were they prepared like the archil. Hellot gives the following method for discovering if they possess this property. A little of the plant is to be put into a glass vessel; it is moistened with ammonia and lime water in equal parts; a little muriate of ammonia (sal ammoniac) is added; and the small vessel is corked. If the plant be of a nature to afford red, after three or four days, the small por-

tion of liquid, which will run off on inclining the vessel, now opened, will be tinged of a crimson red, and the plant itself will have assumed this colour. If the liquor or the plant does not take this colour, nothing need be hoped for; and it is useless to attempt its preparation on the great scale. Lewis says, however, that he has tested in this way a great many mosses, and that most of them afforded him a yellow or reddish-brown colour; but that he obtained from only a small number a liquor of a deep red, which communicated to cloth merely a yellowish-red * colour.

Prepared archil gives out its colour very readily to water, ammonia, and alcohol. Its solution in alcohol is used for filling spirit of wine thermometers; and when these thermometers are well freed from air, the liquor loses its colour in some years, as Abbe Nollet observed.† The contact of air restores the colour, which is destroyed anew *in vacuo* in process of time. The watery infusion loses its colour by the privation of air in a few days; a singular phenomenon, which merits new researches.

The infusion of archil is of a crimson bordering on violet. As it contains ammonia, which has already modified its natural colour, the fixed alkalies can produce little change on it, only deepening the colour a little, and making it more violet. Alum forms in it a precipitate of a brown-red;

* The Chemical Works of Gaspard Neuman.
† Mém. de l'Acad. 1742.

and the supernatant liquid retains a yellowish-red colour. The solution of tin affords a reddish precipitate, which falls down slowly; the supernatant liquid retains a feeble red colour. The other metallic salts produce precipitates that offer nothing remarkable.

The watery solution of archil applied to cold marble penetrates it, communicating a beautiful violet colour, or a blue bordering on purple, which resists the air much longer than the archil colours applied to other substances. Dufay says, that he has seen marble tinged with this colour, preserve it without alteration at the end of two years.

To dye with archil, the quantity of this substance deemed necessary, according to the quantity of wool or stuff to be dyed, and according to the shade to which they are to be brought, is diffused in a bath of water as soon as it begins to grow warm. The bath is then heated till it be ready to boil, and the wool or stuff is passed through it without any other preparation, except keeping that longest in, which is to have the deepest shade. A fine gridelin, bordering on violet, is thereby obtained; but this colour has no permanence. Hence archil is rarely employed with any other view than to modify, heighten, and give lustre to the other colours. Hellot says, that having employed archil on wool boiled with tartar and alum, the colour resisted the air no more than what had received no preparation. But he obtained from herb archil (*l'orseille d'herbe*) a much more durable colour, by putting in the

bath some solution of tin. The archil thereby loses its natural colour, and assumes one approaching more or less to scarlet, according to the quantity of solution of tin employed. This process must be executed in nearly the same manner as that of scarlet, except that the dyeing may be performed in a single bath.

Archil is frequently had recourse to for varying the different shades and giving them lustre; hence it is used for violets, lilacs, mallows, and rosemary flowers. To obtain a deeper tone, as for the deep *soupes au vin*, sometimes a little alkali or milk of lime is mixed with it. The sequel of this browning may also afford agates, rosemary flowers, and other delicate colours, which cannot be obtained so beautiful by other processes. Alum cannot be substituted for this purpose; it not only does not give this lustre, but it degrades the deep colours.

The herb-archil is preferable to the archil of Auvergne, from the greater bloom which it communicates to the colours, and from the larger quantity of colouring matter. It has, besides, the advantage of bearing ebullition. The latter, moreover, does not answer with alum, which destroys the colour; but the herb-archil has the inconvenience of dyeing in an irregular manner, unless attention be given to pass the cloth through hot water as soon as it comes out of the dye.

Archil alone is not used for dyeing silk, unless for lilacs; but silk is frequently passed through a

bath of archil, either before dyeing it in other baths, or after it has been dyed, in order to modify different colours, or to give them lustre. Examples of this will be given in treating of the compound colours. It is sufficient here to point out how white silks are passed through the archil bath. The same process is performed with a bath more or less charged with this colour, for silks already dyed.

Archil, in a quantity proportioned to the colour desired, is to be boiled in a copper. The clear liquid is to be run off quite hot from the archil bath, leaving the sediment at the bottom, into a tub of proper size, in which the silks newly scoured with soap, are to be turned round on the skein sticks with much exactness, till they have attained the wished-for shade. After this, they must receive one beetling at the river.

Archil is in general a very useful ingredient in dyeing; but as it is rich in colour, and communicates an alluring bloom, dyers are often tempted to abuse it, and to exceed the proportions that can add to the beauty, without, at the same time, injuring in a dangerous manner the permanence of the colours. Nevertheless, the colour obtained when solution of tin is employed, is less fugitive than without this addition. It is red, approaching to scarlet. It appears to be the only ingredient which can increase its durability. The solution of tin may be employed, not only in the dyeing bath, but for the preparation of the silk. In this case, by mixing the archil with other

colouring substances, dyes may be obtained which have lustre with sufficient durability.

We have spoken of the colour of the archil, as if it were natural to it, but it is really due to an alkaline combination. The acids make it pass to red, either by saturating the alkali, or by substituting themselves for the alkali.

The lichen which produces archil is subjected to another preparation, to make turnsole (litmus). This preparation is made in Holland. The lichen comes from the Canary Islands, and also from Sweden. It is reduced to a fine powder by means of a mill, and a certain proportion of potash is mixed with it. The mixture is watered with urine, and allowed to suffer a species of fermentation. When this has arrived at a certain degree, carbonate of lime in powder is added, to give consistence and weight to the paste, which is thereafter reduced into small parallelopipeds, that are carefully dried.*

CHAPTER IX.

Of Carthamus.

Carthamus or safflower (*carthamus tinctorius*), the flower of which alone is used in dyeing, is an annual plant cultivated in Spain, Egypt, and the Levant. There are two varieties of it, one which

* Journal des Arts et Manufactures, tom. ii.

has large leaves, and the other smaller ones. It is the last which is cultivated in Egypt, where it forms a considerable article of commerce.

Formerly carthamus was cultivated in Thuringia and Alsace; but the preference given to that of the Levant has caused its culture to be almost entirely abandoned in our climates. The celebrated Beckman, who has given a very interesting dissertation on carthamus,* has sought to discover the difference between that raised in our climate, and that imported from the Levant; but before availing ourselves of his observations, it is proper to describe the properties of this substance, such as it is employed in dyeing.

Carthamus contains two colouring matters, one yellow and the other red. The first, alone, is soluble in water; its solution is always turbid: with reagents, it exhibits the characters usually remarked in yellow colouring matters; the alkalies render it lighter, the acids deepen it, giving it more of an orange hue; both produce a small dun precipitate, in consequence of which it becomes clearer. Alum forms a precipitate of a deep yellow in small quantity. The solution of tin and the other metallic solutions cause precipitates, which have nothing in them remarkable.

Alcohol takes but a slight dye from these flowers, out of which all the yellow substance had been extracted by sufficient washings (with water). If such flowers be put into a solution of caustic

* Comment. Societ. Gotting. tom. iv. 1774.

alkali, they become yellow, and the liquor expressed from them is of a deep yellow. On saturating the alkali with an acid, the liquor becomes turbid, reddish, and deposites a reddish-yellow precipitate in small quantity. A yellow precipitate is formed, with solutions of alum, zinc, and tin; and a precipitate bordering on green, with solutions of iron and copper. If a carbonate of an alkali has been used, the acids produce an abundant and a redder precipitate; but the shade differs according to the acid employed. Alum produces also with the latter alkaline solution a red precipitate, which is so light that it usually floats on the surface of the liquor. This colouring matter is so delicate, so easily affected, that if heat be employed for dissolving it, the precipitates by the acids have no longer the same beautiful colour.

Beckman has observed, that the carthamus of Thuringia contains far more yellow matter than that of the Levant; that in other respects the red matter of the former did not yield in beauty to that obtained from the latter; but that in order to obtain an equal effect, one-half more of the one was required than of the other. He inquired if this difference depended on climate, or only on the preparation.

Hasselquist relates, in his *Voyage d'Egypte*, that when the flowers of carthamus are gathered, they are squeezed between two stones to express their juice; that they are thereafter washed several times with pit-well water, which in Egypt is naturally

saltish; that, on coming out of the water, they are pressed between the hands, and then spread out on mats upon terraces; that they are covered during the day, to hinder the sun from drying them too much; but that they are exposed to the dew during the night; that they are turned over from time to time; and that when they are found to be dried to the proper point, they are taken up, and preserved for the market, under the name of *safranon* (safflower).

If the carthamus of the Levant, as found in commerce, be compared with that of Thuringia, the former is observed to be purer, a little damp, and in compressed masses; while the latter is drier and more elastic. These differences depend on the preparation. The authors on agriculture, misled by the false denomination of bastard saffron, given to carthamus, have thought it should be treated like saffron. They consequently direct to gather it in a dry season, and also to dry it with much care. Beckman conceives that we should, on the contrary, imitate the method adopted in Egypt; he recommends to add even a little salt to the water used in the preparation, that it may have the same quality as in Egypt.

The flower of carthamus has a fine flame colour; it should be gathered only when it begins to fade, and it is better when it has received rain in this state, although there be a prejudice to the contrary. The rain may be supplied by an artificial watering of the flowers morning and evening,

The seeds may still be left to ripen after the blossom is cropped.

These directions are given with the view of separating the yellow substance, a redundance of which may constitute the difference between the carthamus of our climate, and that of the Levant. It is proper to keep the carthamus in a moist place, for too strong desiccation might injure it.

Many motives should induce us to enrich our agriculture with this production. The seeds of carthamus serve as a very good nourishment to poultry, but particularly to parrots, whence they have got the name of parrot seeds *(graine de perroquet)*. A useful oil may be expressed from them, and the residue may be given to cattle. The dry leaves and twigs may serve as fodder to sheep and goats during winter; and the stronger stems, which the animals have stripped, may be used for fuel. Beckman has proved, that carthamus ripened well at Gottingen, where the soil is sandy. The ground should be dunged in moderation, and the plant must be neither watered nor transplanted. We have seen some of it grown at Amiens by the cares of Lapostolle, which was of good quality.

The yellow matter of carthamus is not employed; but in order to extract this portion, the carthamus is put into a bag, which is trodden under water, till no more colour can be pressed out. The flowers, which were yellow, become reddish, and lose in this operation nearly one-half of their weight. In this state they are used.

The yellow colouring substance might however be employed. Poerner has made several experiments on this subject. Their principal result is, that wool takes without preparation a yellow hue which is not durable, but that which it takes after alum and tartar is better, although it is not very permanent. Beckman says, that cloth prepared with tartar, or with tartar and alum, takes a good yellow colour, and that, in equal weight, carthamus contains more yellow colouring matter than yellow wood (old fustic) itself.

For extracting the red part of carthamus, and thereafter applying it to stuff, the property which alkalies possess of dissolving it is had recourse to, and it is afterwards precipitated by an acid. Beckman says, that next to citric acid (acid of lemons), sulphuric acid has the best effect, provided only the due proportion be employed; otherwise it alters and destroys the colour. According to Scheffer, we may substitute for lemon juice, the juice of the berries of the mountain-ash *(sorbus aucupatorius)*, which is to be thus prepared. These berries are to be beat in a mortar with a wooden pestle, and the juice is to be strained off, and allowed to ferment. It is then put into bottles; and the clear portion, which is sourest, is better fitted for this process the older it is. This preparation requires some months, and should be undertaken only in summer.

The process of dyeing consists, therefore, in extracting the red colouring matter by means of an

alkali, and precipitating it on the stuff by means of an acid. It is this fecula which serves for making the rouge employed by ladies.

As to this rouge, the solution of carthamus is prepared with crystallized carbonate of soda, and it is precipitated by lemon juice. It has been remarked, that lemons beginning to spoil were fitter for this operation, than those that were less ripe, whose juice retained much mucilage. After squeezing out the lemon juice, it is left to settle for some days. The precipitate of carthamus is dried at a gentle heat, on plates of stone-ware; from which it is detached and very carefully ground with talc, which has been reduced to a very subtile powder, by means of the leaves of shave grass *(presle)*, and successively passed through sieves of increasing fineness. It is the fineness of the talc, and the greater or less proportion which it bears to the carthamus precipitate, which constitute the difference between the high and low priced *rouges*.

Wool may be dyed red by means of carthamus, as Beckman has ascertained. This dye passes, however, very readily to orange, and the power of obtaining from cochineal the finest and most varied reds, which are at the same time much more permanent than those of carthamus, makes the latter be rejected for wool.

Carthamus is used for dyeing silk, poppy, *nacarat* (a bright orange-red), cherry, rose colour, and flesh colour. The process differs, according to the intensity of the colour, and the greater or less

tendency to flame colour that is wanted. But the carthamus bath, whose application may be varied, is prepared as follows.

The carthamus, from which the yellow matter has been extracted, and whose lumps have been broken down, is put into a trough. It is repeatedly sprinkled with *cendres gravelées* (crude pearl ashes), or soda (barilla) well powdered and sifted, at the rate of 3 kilogrammes for 50 kilogrammes of carthamus: but soda is preferred; mixing carefully as the alkali is introduced. This operation is called *amestrer*. The *amestred* carthamus is put into a small trough with a grated bottom, first lining this trough with a closely woven cloth. When it is about half filled, it is placed over the large trough, and cold water is poured into the upper one, till the lower becomes full. The carthamus is then set over another trough, till the water comes from it almost colourless. A little more alkali is now mixed with it, and fresh water is passed through it. These operations are repeated till the carthamus be exhausted, when it turns yellow.

After distributing the silk in hanks on the rods, lemon juice, brought in casks from Provence, is poured into the bath, till it becomes of a fine cherry colour; this is called *turning* the bath *(virer le bain)*. It is well stirred; and the silk is immersed, and turned round the skein sticks in the bath, as long as it is perceived to take up the colour. For *ponceau* (poppy colour), it is withdrawn, the liquor is wrung out of it on the peg,

and it is turned through a new bath, where it is treated as in the first. After this it is dried and passed through fresh baths, continuing to wash and dry it between each operation, till it has acquired the depth of colour that is desired. When it has reached the proper point, a brightening is given it, by turning it round the sticks seven or eight times in a bath of hot water, to which about half a pint of lemon juice for each pailful of water has been added.

When silk is to be dyed *ponceau* or flame colour, it must be previously boiled as for white; it must then receive a slight foundation of annotto, as will be explained in treating of this substance. The silk should not be alumed.

The *nacarats*, and the deep cherry colours, are given precisely like the *ponceaux*, only they receive no annotto ground; and baths may be employed which have served for the *ponceau*, so as to complete their exhaustion. Fresh baths are not made for the latter colours, unless there be no occasion for the poppy.

With regard to the lighter cherry-reds, rose colours of all shades, and flesh colours, they are made with the second and last runnings of the carthamus, which are weaker. The deepest shades are passed through first.

The lightest of all these shades, which is an extremely delicate flesh colour, requires a little soap to be put into the bath. This soap lightens the colour, and prevents it from taking too speedily, and becoming unevenly. The silk is then

washed, and a little brightening is given it, in a bath which has served for the deeper colours.

All these baths are employed the moment they are made, or as speedily as possible, because they lose much of their colour on keeping, by which they are even entirely destroyed at the end of a certain time. They are, moreover, used cold, to prevent the colour from being injured. It must have been remarked in the experiments just described, that the pure alkalies attack the extremely delicate colour of carthamus, making it pass to yellow. This is the reason why crystals of soda are preferred to the other alkaline matters. Those at least should be selected which contain most carbonic acid, as salt of tartar.

In order to diminish the expense of the carthamus, it is the practice, for the deeper shades, to mingle with the first and the second bath about 1-5th of the bath of archil.

For dyeing on raw silks, such as are very white should be chosen, and be treated like boiled silks, with this single difference, that the poppies, the nacarats, the cherries, should be commonly passed through the baths which have already served to make the same colours with boiled silk, because raw silk is, in general, more easily dyed than boiled.

The poppy having been prepared in an acid liquid, resists the proof by vinegar; but it is speedily altered and destroyed in the air. Scheffer says, that the colour for which mountain-ash

berry juice has been used instead of lemon juice, resists for a longer period.

Beckman made experiments on the application of the red colour of the carthamus to cotton.* He macerated cotton for two hours in melted hog's lard; he washed it well, and after this dyed it, in the ordinary way, with carthamus deprived of its yellow matter. This cotton took a deeper colour than that which had received no preparation. Soap succeeded equally well, olive oil still better. Beckman next passed cotton several times through oil, drying it alternately. After the last drying, he washed and dried it. He passed it through the yellow bath of carthamus, to which he added nut-galls and alum; and, lastly, he dyed it with the alkaline solution of carthamus and lemon juice. He thus obtained a beautiful and saturated red colour. The cotton treated without being impregnated with oil, took a colour of the same kind, but it was less saturated, and withstood less the action of the air. The author, from these experiments, imagines that it would be necessary to give cotton that is to be dyed with carthamus, preparations analogous to what it receives in the Adrianople red dye.

To dye cotton, poppy, Wilson directs us to put the carthamus, well freed from its yellow colouring matter, into a vessel having a hair sieve near its bottom, and to pour over it a solution of pearl

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In Egypt, there is given to cotton, and even linen, a very saturated and somewhat permanent colour, by means of carthamus. The carthamus is subjected to two successive macerations, each of 24 hours, in pit-well water slightly alkaline. After this it is mixed with 1-5th of its weight of (alkaline) ashes, purchased from the Arabs, which contain a little carbonate of soda. This mixture is ground in a mill; and some water of the Nile is then filtered through it. By this means, a liquid strongly charged with colouring matter is obtained. They commence dyeing with the por-

st filtered, which is feebly charged; they
o it a little lemon juice; then mix in a
first portion of the liquid, with a consi-
tity of lemon juice, and dye at a heat
50° Reaumur. They finish, by passing
off through an acidulous water, and drying

CHAPTER X.

Of Brazil Wood.

THIS wood, which is much used in dyeing, derives its name from the part of America whence it was first imported. It has also the name of Fernambucca, wood of Saint Martha, or of Sapan, according to the places which produce it. At present it is cultivated in the Isle of France, where it has been naturalized. That of the Antilles, called *brésillet braziletto*, is least esteemed.

Linnæus distinguishes the tree which furnishes the Brazil wood, by the name of *cæsalpinia crista;* that of Japan, or the wood of Sapan, distinguished into the large and little Sapan wood, by the name *cæsalpinia sapan;* and, lastly, he denominates the *brésillet, cæsalpinia vesicaria.*

This tree commonly grows in dry places, and amid rocks. Its trunk is very large, crooked, and full of knots. The flowers of the wood of Sapan,

* Mémoires sur l'Egypte.

washed, and a little brightening is given it, in a bath which has served for the deeper colours.

All these baths are employed the moment they are made, or as speedily as possible, because they lose much of their colour on keeping, by which they are even entirely destroyed at the end of a certain time. They are, moreover, used cold, to prevent the colour from being injured. It must have been remarked in the experiments just described, that the pure alkalies attack the extremely delicate colour of carthamus, making it pass to yellow. This is the reason why crystals of soda are preferred to the other alkaline matters. Those at least should be selected which contain most carbonic acid, as salt of tartar.

In order to diminish the expense of the carthamus, it is the practice, for the deeper shades, to mingle with the first and the second bath about 1-5th of the bath of archil.

For dyeing on raw silks, such as are very white should be chosen, and be treated like boiled silks, with this single difference, that the poppies, the nacarats, the cherries, should be commonly passed through the baths which have already served to make the same colours with boiled silk, because raw silk is, in general, more easily dyed than boiled.

The poppy having been prepared in an acid liquid, resists the proof by vinegar; but it is speedily altered and destroyed in the air. Scheffer says, that the colour for which mountain-ash

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Beckman made experiments on the application of the red colour of the carthamus to cotton.* He macerated cotton for two hours in melted hog's lard; he washed it well, and after this dyed it, in the ordinary way, with carthamus deprived of its yellow matter. This cotton took a deeper colour than that which had received no preparation. Soap succeeded equally well, olive oil still better. Beckman next passed cotton several times through oil, drying it alternately. After the last drying, he washed and dried it. He passed it through the yellow bath of carthamus, to which he added nut-galls and alum; and, lastly, he dyed it with the alkaline solution of carthamus and lemon juice. He thus obtained a beautiful and saturated red colour. The cotton treated without being impregnated with oil, took a colour of the same kind, but it was less saturated, and withstood less the action of the air. The author, from these experiments, imagines that it would be necessary to give cotton that is to be dyed with carthamus, preparations analogous to what it receives in the Adrianople red dye.

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water. He recommends us to dry in the shade the cottons which have received these colours.*

To Brown, who is engaged with much zeal in the arts, we are indebted for a process which is used for a crimson on cotton in some manufactories.

A solution of tin is prepared in the following proportions: Nitric acid four parts; muriatic acid, two parts; tin, one part; water, two parts. The liquids are to be mixed, and the tin dissolved in them, by adding it in small bits at a time.

For a piece of cotton velvet, weighing from seven to eight kilogrammes, we begin by preparing a bath composed of four parts of boiling water, and two parts of a strong decoction of nutgalls. The bath is raked up, the piece is let down into it, worked there for half an hour, and allowed to remain for two hours more; at the end of this time it is taken out, and set to drain. Another bath is prepared with three pailfuls of boiling water, and one pailful of decoction of wood of Fernambucca, also boiling. It is raked, and the piece is worked in it for an hour. This bath is emptied, and the vat washed out, and then filled with a clean boiling-hot decoction of wood. The piece is worked in this for half an hour, and lifted up on a winch. A bath of very clear river water is now got ready, into which a litre of

* Versuche und bemerkungen zum nutzen der farbekunst weiter theil.

solution of tin is poured. After the bath is raked, the piece is worked in it for a quarter of an hour. It is then lifted on the winch, carried back above the vat containing the bath of decoction of fernambucca wood, one-sixth of which is taken out and replaced by an equal quantity of boiling solution. After raking up, the piece is worked in this bath for half an hour. It is raised upon the winch, and then transferred to the vat containing the solution of tin. This alternate working is repeated six or eight times, observing to withdraw each time one-sixth of the bath of fernambucca wood, and to replace it by an equal quantity of the boiling decoction of the same wood; to stir the bath of the composition every time with the rake; and to finish the dye by leaving it in the last bath. The piece is washed in a stream of water, and it is carefully dried in a dark place.

An analogous process is used for making the *mordorés*. After galling the cotton, it is alumed and maddered with an intermediate drying; it is next passed through the fernambucca, and the solution of tin. Some persons substitute muriate of tin for this solution.

In investigating the means best adapted to procure more permanence to the beautiful and varied colours that are obtained at little expense from brazil wood, it is proper to recapitulate some of its properties.

The colouring particles of brazil wood are easily affected, and made yellow by the action of acids.

They thus become permanent colours. But what distinguishes them from madder and kermes, and approximates them to cochineal, is their reappearing in their natural colour, when they are thrown down in a state of combination with alumina, or with oxide of tin. These two combinations seem to be the fittest for rendering them durable. It is requisite, therefore, to inquire what circumstances are best calculated to promote the formation of these combinations, according to the nature of the stuff.

The astringent principle, likewise, seems to contribute to the permanence of the colouring matter of brazil wood; but it deepens its hue, and can only be employed for light shades.

The colouring particles of brazil wood are very sensible to the action of alkalies, which give them a purple hue; and there are several processes in which the alkalies, either fixed or volatile, are used for forming violets and purples. But the colours obtained by these methods, which may be easily varied according to the purpose, are perishable, and possess but a transient bloom. The alkalies appear not to injure the colours derived from madder, but they accelerate the destruction of most other colours.

In England and Holland the dye-woods are reduced to powder by means of mills erected for the purpose. It appears, from the statement of Wilson, that they are kept moistened with urine, or, if this be not used, a little alkali is added when they are to be boiled.

The practice of reducing these woods to powder is of advantage, and ought to be generally adopted. In the Journal of Arts and Manufactures (French), volume first, is a description of the mills employed in Holland, and of the operations to which the dye-woods are subjected. When the woods are employed, and especially if they be in powder, it is proper to put them into a bag, before introducing them into the dyeing baths. Putrefied urine and alkali, by promoting the extraction of the colouring particles, and increasing the tone of their colour, may frequently be hurtful to the effect wished to be obtained, or may accelerate their destruction. (NOTE MM.)

CHAPTER XI.

Of Logwood.

LOGWOOD (*bois d'Inde*), wood of Campeachy, or of Jamaica, has received these different names from the places where it grows most plentifully. It is very common in Jamaica, and on the eastern shore of the Bay of Campeachy. It is found also at Santa Cruz, Martinique, and Grenada.

Linnæus calls the tree *hæmatoxylum campechianum*. It grows to a great height and thickness in a favourable soil. Its bark is thin, smooth, of a brilliant grey, and sometimes yellowish. Its trunk is straight, furnished with thorns: its leaves

have some resemblance to those of the laurel, to which they also approach in their aromatic quality, whence the tree has got the name of the *aromatic* or *Indian* (bay) *laurel.* As its seeds have the taste of cloves, they have improperly got the name of *clove-seeds* (*graines de girofle*). The English call them *Jamaica pepper*, or *all-spice.*

Logwood is so heavy as to sink in water. It is hard, compact, of a fine grain, capable of being polished, and scarcely susceptible of decay. Its predominant colour is red, with orange, yellow, and black tints.

For use, its juice is usually extracted like that of brazil wood. It yields its colour to both spirituous and watery menstrua. Alcohol extracts it more readily and abundantly than water. The colour of its tinctures is a fine red, bordering a little on violet or purple, which is principally observable in its watery decoction. This left to itself becomes in time yellowish, and finally black. Acids change it to yellow, and the alkalies deepen its colour, bringing it to a purple or violet. Sulphuric, nitric, and muriatic acid, occasion in it a slight precipitate, long in falling, which is of a dark red, with sulphuric acid, a dead-leaf (*feuille-morte*) colour with the nitric, and a lighter red colour with the muriatic. The supernatant liquor is transparent, of a deep red colour with the sulphuric and muriatic acids, and yellowish with the nitric. Oxalic acid forms a bright (*marrone*) chesnut precipitate: the liquor remains transparent, of a yellowish red. Acetic acid comports

itself in nearly the same way, only the colour of the precipitate is a little deeper. Tartar gives a precipitate like vinegar; but the liquor remains turbid, and inclines more to yellow. Fixed alkali forms no precipitate, but causes the solution to pass to deep violet, which eventually becomes almost brown. Alum occasions a pretty abundant precipitate, of a light violet hue: the liquor remains violet, and nearly transparent. Alum and tartar together produce a pretty copious red-brown precipitate: the liquor remains transparent, and of a yellowish-red. Sulphate of iron gives immediately a bluish-black colour, like that of ink, a precipitate is formed of the same colour, and the liquor remains long turbid; but if it be sufficiently diluted, and especially if there be a slight excess of sulphate, the whole black matter finally falls down. Sulphate of copper produces a very copious precipitate, of a browner and less brilliant black than the preceding. The liquid remains transparent, of a very deep yellowish or brownish-red. Acetate of lead causes immediately a black precipitate, with a slight reddish tint. The liquid remains transparent, of a pale beer colour, and very bright. Lastly, tin dissolved in nitro-muriatic acid instantly forms a precipitate of a very fine violet colour, or purple, almost *prune de monsieur*. The supernatant liquor is very clear and totally colourless.

Stuffs would take in the decoction of logwood but a feeble and fugitive colour, were they not

previously prepared with alum and tartar. A little alum is also added to the bath. By this means they take a pretty fine violet.

A blue colour may be obtained from logwood by mingling verdigris with the bath, and passing the cloth through it till it has taken the desired shade.

These uses of logwood have obtained for it the names of *violet wood* and *blue wood*. When treating of the compound colours, these hues will be more fully considered.

The main employment of logwood is for blacks, to which it gives lustre and velvetiness; and for greys of certain shades. It is very extensively used also for different compound colours, which it would be difficult to obtain as beautiful and as diversified by the ingredients of a more permanent dye.

The juice of logwood is often mixed with that of brazil wood, to render the colours of a variable depth, according to the proportions in which this mixture is made.

Logwood is used for dyeing silk violet, prior to which the silk must be scoured, alumed, and washed, because without aluming it would take only a reddish tint, which would not bear wetting. This dye must be performed by turning the silks cold round their skein sticks in the decoction of logwood till they have acquired the colour that is wanted, because with heat there is obtained merely a speckled and uneven colour.

Bergman long ago remarked, that a more beautiful and permanent violet might be formed from logwood, by impregnating the silk with a solution of tin, as has been stated in the preceding chapter. There is thus obtained, indeed, especially by mixing the logwood with brazil wood in different proportions, a great many beautiful shades, bordering more or less on red, from lilac to violet.

If decoction of logwood be employed for that of brazil wood in the process communicated by Brown, a fine violet colour is obtained; and if the two decoctions be mixed together, shades of puce (flea-brown) and *prune de monsieur* will be got, inclining more or less to red.

The observations which have been given on brazil wood are applicable to logwood, whose colouring matter presents analogous properties. We shall only add, that in order to determine the differences resulting from the state of oxidation of the tin, when its solutions are used, we precipitated a decoction of fernambucca, and a decoction of logwood, with the proto-muriate of tin, and with the highly oxidized muriate. The lakes thrown down by the former had at first less lustre; but on exposure to air they soon acquired the same tone as those proceeding from a highly oxidized salt. We have, in like manner, impregnated silk with the solution of the same salts, and then dyed them with brazil wood and with logwood, when the superiority of colour was in

favour of the patterns which had received the least oxidized salt.

When logwood has been employed in a process without solution of tin, it may be recognized by the red colour which the dyed stuff receives from an acid. (NOTE NN.)

SECTION IV.

OF YELLOW.

CHAPTER I.

Of Weld.

WELD, or woald (*la gaude* or *vaude* in French, *reseda luteola, Linn.*), is a very common plant in the neighbourhood of Paris, in the greater number of our departments, and a great portion of the rest of Europe.

This plant puts forth long narrow leaves of a lively green. From the midst of these leaves the stem rises to about the height of a yard. It is often branchy, furnished with narrow leaves like the radical ones, but shorter as they approach the flowers, which are disposed in long spikes. The whole plant except the root serves for dyeing yellow.

Two kinds of weld are distinguished,—the wild or bastard weld, which grows naturally in the fields,—and the cultivated weld, which pushes forth stems of less height and thickness. The

latter is preferred for dyeing; it abounds much more in colouring matter. It is esteemed in proportion to the slenderness of the stalks.

When the weld is ripe it is plucked up, allowed to dry, and put up in bundles. In this state it is employed.

When the decoction of weld is highly charged it has a yellow colour bordering on brown; when much diluted with water, its yellow is more or less pale, and inclines a little to green.

If a little alkali be added to this decoction its colour deepens, and there takes place after a certain time a slight ash-coloured precipitate insoluble in the alkalies.

The acids in general render its colour paler, and occasion a small precipitate, which alkalies dissolve, with the assumption of a yellow colour verging on brown.

Alum forms with it a yellowish precipitate: the supernatant liquid retains a fine lemon colour. If a solution of alkali be poured into this liquid, a precipitate forms of a whitish-yellow, soluble in alkalies, but the liquid remains always coloured.

The solution of muriate of soda, and that of muriate of ammonia, make the liquor turbid, and at first of a somewhat deeper hue. By degrees a precipitate falls of a deep yellow, and the supernatant liquid retains a pale yellow colour, inclining a little to green.

The solution of tin produces an abundant precipitate of a bright yellow; the liquor continues long turbid, but little coloured.

Sulphate of iron produces a copious grey-black precipitate; the supernatant liquid retains a brownish colour.

Sulphate of copper causes a brownish green precipitate; the liquor preserves a pale green colour.

The yellow colour which weld communicates to wool has little permanence, if the wool has not been previously prepared with some mordants. Alum and tartar are employed; and by this means the plant affords the purest yellow,—a colour which possesses the advantage of being durable.

For the *bouillon*, which is performed in the usual manner, Hellot prescribes four parts of alum for sixteen of wool, and only one of tartar. Several dyers, however, employ half as much tartar as alum. Tartar renders the colour lighter, but more lively.

For the *welding (gaudage)*, that is to say, dyeing with weld, the plant enclosed in a thin bag is boiled in a fresh bath, which is loaded with a heavy wooden cross, that it may not rise to the surface of the bath. Some dyers let it boil till it falls to the bottom of the copper, after which they lay on it a *champagne* (a weight to press it down). Others rake it out when it is boiled, and throw it away.

Hellot prescribes from five to six parts of weld for one part of cloth; but so considerable a quantity is seldom employed, dyers contenting them-

selves with three or four parts, or even much less. It is true that several dyers add to the weld a little quicklime and ashes, which favour the extraction of the colouring matter, and heighten its colour, but render it at the same time liable to change by the action of acids. The quantity of weld, however, should be proportioned to the depth of shade wanted.

It is possible to dye in the sequel of the first dippings, in order to obtain progressively paler shades, by adding water at each dipping (*mise*), and keeping the bath boiling; but the light shades obtained by this means have not so much vivacity as when fresh baths are used, proportioning the quantity of weld to the shade desired.

If muriate of soda be added to the weld bath, its colour becomes richer and deeper. Sulphate of lime or gypsum renders it also deeper; but alum makes it lighter and brighter, and tartar paler. Sulphate of iron, or vitriol, causes it to draw towards brown. The hues obtained from weld may be modified by similar additions, by the proportions of the weld, by the duration of the operation, and by the mordants employed for the preparation of the stuff. Thus Scheffer says, that by boiling the wool for two hours with one-fourth of solution of tin, and one-fourth of tartar, washing it, and boiling it 15 minutes with an equal quantity of weld, it takes a beautiful colour, but one which does not penetrate into the interior. Poerner directs us also to prepare the cloth as for

the scarlet dye. By this means, more lustre and permanence are given to the colour, which, *cæteris paribus*, is also brighter.

The colour may be farther modified by passing the cloth, on its coming out of the dye, through another bath. Thus, to make a golden yellow, the cloth, on its leaving the welding, is to be turned through a slight bath of madder; and to give it a tan colour, it is to be passed through a bath made with a little soot. These methods will be spoken of in treating of saddenings (*brunitures*).

To dye silk of a plain yellow (*jaune franc*), no other ingredient is commonly used except weld. The silk must be scoured at the rate of 20 pounds of soap to the 100; afterwards alumed and refreshed, that is to say, washed after the aluming.

A bath is made with two parts of weld for one of silk, and after a full quarter of an hour's ebullition, it is filtered through a sieve, or cloth, into a vat. When this bath is sufficiently cooled to allow the hand to be plunged into it, the silk is immersed and turned round the sticks till it be uniform. During this operation, the weld is boiled a second time in fresh water. About one-half of the first bath is thrown out, and it is replaced by the second *bouillon*. This fresh bath may be employed a little hotter than the first; too great a heat, however, must be avoided, by which a portion of the colour already attached would be dissolved. It is to be turned as before, and meanwhile, some crude pearl ash is to be dis-

solved in a portion of the second *bouillon*. The silk is to be taken out of the bath, in order to add to it more or less of this solution, according to the shade that is wanted. After some turnings, a hank is wrung with the pin, to see if the colour be sufficiently full and golden. If it be not enough so, a little more of the alkaline solution is added, the property of which is to deepen the colour, and give a golden hue. The process is continued, as before, till the silk has attained to the wished-for shade. The alkaline solution may be added also, at the same time, with the second *bouillon* of weld, always taking care that the bath be not too hot.

If more golden-yellows be wanted, bordering on jonquille, it is necessary, when the ashes are put into the bath, to add some annotto, in proportion to the shade desired.

For the light yellow shades, as pale lemon and canary, the silk must be scoured as for blue, because these shades are more beautiful and transparent the whiter the ground is on which they are placed. The strength of the bath is proportioned to the shade sought for. If the yellow be wished to have a cast verging on green, more or less of the (indigo) vat is added, if the silk has been scoured without azure. To prevent these shades from being too deep, a slighter aluming than usual may be given to the silk.

Scheffer directs us to soak the silk for 24 hours in a solution of tin, prepared with four parts of nitric acid, one of muriate of soda, and one of

tin, the solution being saturated with tartar; to wash it, and boil it for half an hour with its own weight of flowers of weld. He says, that a fine straw colour is thereby obtained, which has the advantage of resisting the acids. In adopting this process, very little tin must remain in the solution, because the tartaric acid throws it down. The observations which we have previously made on the use of tin, may be applied here.

For dyeing cotton yellow, the first thing is to scour it in a bath prepared with a lixivium of the ashes of green wood, then to wash and dry it. It is alumed with the fourth of its weight of alum. After 24 hours it is taken out of the aluming and dried, without washing. A weld bath is thereafter prepared, at the rate of one part and a quarter of weld for one of cotton. In this the cotton is dyed, by turning it round the sticks, and working it with the hands, till it has acquired the wished-for shade. It is taken out of this bath to be macerated for an hour and a half in a solution of sulphate of copper or blue vitriol, in the proportion of one-fourth of this salt to one part of cotton. It is next thrown, without washing it, into a boiling solution of white soap, made in the same proportions. After being well stirred, it is to be boiled for nearly an hour, after which it must be well washed and dried.

If a deeper yellow, bordering on jonquille, be wanted, the cotton is not passed through the aluming, but two parts and a half of weld are employed to one of cotton, with the addition of a

little verdigris dissolved in a portion of the bath. The cotton is plunged into it, and worked, till it has taken an uniform colour. It is lifted out of the bath that a little soda ley may be poured in, when it is again immersed and turned through the bath for a full quarter of an hour. It is then withdrawn, wrung, and dried.

Lemon yellow is made by the same process, except that only one part of weld is used (for one of cotton), while the quantity of verdigris can be diminished in proportion, or even entirely omitted, and aluming put in its place. Thus the shades of yellow may be varied in many ways. The operations on linen yarn are the same.

For the yellow colours on printed cotton goods, these are impregnated, by means of engraved plates, with the mordant described in treating of madder, formed by the mixture of acetate of lead and alum : the yellow colour induced on the parts not impregnated with the acetate of alumina, is to be afterwards destroyed by the action of bran, and exposure on the grass. The same mordant may be successfully employed for cotton and linen which is to be dyed yellow.

In order to obtain from weld the whole colour that it can yield, it must be boiled for three-quarters of an hour; the bundles of weld are now taken out of the bath, after which the cloths are passed through it, at a temperature a little below ebullition. They should not remain in it more than twenty minutes.

When the same piece of cloth is to exhibit the colours produced by both madder and weld, it is necessary to begin with the maddering, and not to print on the mordant intended for the weld till the operations of the madder are finished. This rule is founded on the property which madder possesses of fixing itself in the room of the yellow of weld; so that if the maddering be long continued after dyeing with weld, the colour of the latter entirely disappears. Weld, on the contrary, does not affect the colour produced by madder, provided the mordant has been saturated with the latter, for otherwise a mixed colour would be produced.

The operations required for restoring the white are much longer, and demand much nicer management, after welding than after maddering.

CHAPTER II.

Of Fustic (Bois Jaune).

This is the wood of a large tree (*morus tinctoria*), which grows in the Antilles, and principally at Tobago. It is of a yellow colour, as its name denotes, and it has orange veins. Its medullary prolongations are very thin. It is neither very hard nor heavy.

The use of this wood for dyeing has only become general of late years. It abounds much in colouring matter, affording a colour which is

permanent, especially on woollen stuffs. It unites well with indigo; has a moderate price; and its qualities entitle it to rank among the most valuable ingredients in dyeing.

A strong decoction of this wood has a deep yellow-red colour; when diluted with water, it becomes orange-yellow. The acids make this liquid turbid, with some inconsiderable differences; a slight greenish-yellow precipitate falls, and the supernatant liquid is of a pale yellow. The alkalies redissolve the precipitate, and give the liquor a deep reddish colour.

This is the colour which alkalies give to the decoction of fustic; they render it deeper and almost red. There is formed, with time, a deposite of a yellowish substance, which adheres to the vessel, and sometimes floats on the top.

Alum forms a small quantity of a yellow precipitate; the liquor remains transparent, and of a less deep yellow.

Alum and tartar together, afford a precipitate which has the same colour, but it is slower in falling. The liquor retains a still deeper hue.

The muriate of soda makes the colour a little deeper, without occasioning turbidity.

Sulphate of iron forms a precipitate at first yellow, but which grows more and more brown; the liquor continues brown, and without transparency.

Sulphate of copper affords an abundant precipitate of a brown-yellow; the supernatant liquor retains a feeble greenish colour.

Sulphate of zinc yields a greenish-brown precipitate; the liquor retains a reddish-yellow colour.

Acetate of lead forms an abundant orange-yellow precipitate; the liquor is transparent, and of a very faint greenish-yellow.

The solution of tin gives a very copious precipitate of a fine yellow, a little brighter than the preceding; the liquor retains a faint yellow colour.

For use, yellow wood is cleaved into splinters, or, what is better, reduced into chips or powder; it is then enclosed in a bag, to prevent some portions of it from fixing on the stuff and tearing it.

Weld gives to cloth which has received no preparation, only a pale yellow, which does not long resist the action of the air; but yellow wood produces, without the aid of mordants, a yellow colour, bordering on brown, which, though dull, resists the air better. Vivacity is given to its colour, and its permanence is augmented by the mordants employed for weld, which exercise on it an action altogether analogous: thus alum, tartar, and solution of tin, render its colour brighter; sea salt and sulphate of lime deepen its hue. The processes which have been pointed out for weld, may therefore be applied to fustic, with this difference, that in order to obtain the same shade, much less yellow wood must be employed. Thus from 5 to 6 parts of this wood are sufficient to give a lemon colour to 16 parts of cloth. The colours, however, obtained by these processes,

incline more to orange, and are duller than those of weld. Occasionally, the two are mixed, according to the effect wished to be obtained.

To Chaptal we owe an easy means of procuring from fustic a livelier colour. Having remarked that the decoction of this wood gave a precipitate with gelatin, and that a fine yellow colour was then obtained from it, he prescribes, *to boil in the bath of yellow wood, parings of skins, glue, or other animal matters; and then, without filtering, the stuff is to be worked in it, which will thus take the most beautiful and intense colour.**

CHAPTER III.

Of Quercitron.

To Bancroft we are indebted for this dye-stuff. He has given an ample description of its properties, and of the uses to which it is adapted. We shall here exhibit a summary account of them.

Quercitron is the bark of the *Quercus nigra* of Linnæus. The epidermis, which yields a brownish colour, must be separated carefully from the bark; after which this is reduced to powder in a mill.

This powder affords as much colouring matter as 8 or 10 parts of weld, and 4 of fustic. Its colour possesses a great analogy to that of weld, but it is much cheaper.

* Mém. de l'Institut, tom. i.

Quercitron readily yields its colouring matter to water merely tepid. An extract is obtained from it, amounting to 1-12th the weight of the bark; but it is difficult to employ this in dyeing, because if a boiling heat be used, its colour becomes brownish; and if the evaporation takes place slowly, it suffers another kind of alteration.

The decoction of quercitron is of a brownish-yellow colour. The alkalies deepen, and the acids brighten it. The solution of alum separates a very small portion of its colouring matter, which forms a deep yellow precipitate. The solutions of tin produce a more copious precipitate of a lively yellow. Sulphate of iron affords a plentiful precipitate of a deep olive colour; the supernatant liquor is clear, and of a light olive-green.

For dyeing wool, it is sufficient to boil the quercitron with its own weight, or one-third more than its weight, of alum, for two minutes. The stuff is then introduced, and the deepest shades are given at first, ending with straw colour. These colours may be brightened, by passing the stuff on quitting the bath through hot water, whitened with a little washed chalk. But the colour obtained by this process is not so permanent as when the stuff is subjected to a *bouillon* before passing it through the dyeing bath. In this second method, the stuff is boiled for an hour, or an hour and a quarter, in a solution of alum, containing one-sixth or one-eighth of the weight of the wool. No tartar should be used. It is next dyed in a bath prepared with a weight of quercitron equal

to that of the alum employed, till the colour be sufficiently raised. Chalk being now introduced into the bath to brighten the colour, the stuff is let down anew for 8 or 10 minutes.

A brighter colour is obtained by means of solution of tin. Bancroft directs us to employ for the bath an equal weight of quercitron and solution of tin in nitro-muriatic acid, (or rather in the mixture of nitric and sulphuric acids, of which we have spoken in treating of scarlet). When a brilliant golden-yellow colour is wanted, verging on orange, only 7 or 8 parts of solution of tin are employed for 10 of quercitron and 5 of alum. A little tartar added to these ingredients gives a lemon colour, bordering on green, which has hitherto been thought to be obtainable only by weld.

Quercitron may be substituted for weld, for the different shades given to silk, which should first be alumed. The dose is from 1 to 2 parts of quercitron for 12 of silk. The colour may be brightened by adding a little chalk or potash towards the end of the operation. The solution of tin may also be used along with alum, which should be in larger proportion.

In the substitution of quercitron for weld in calico printing, Bancroft prescribes, after the preliminary operations of printing, to diffuse the powdered quercitron in cold water, to introduce the pieces to be dyed, and to heat the bath by degrees, turning the cloth slowly round the winch. The colour is livelier and more durable,

if the heat be raised only a little above the temperature of the human body, than when it approaches nearer to ebullition. The intensity of the yellow may be varied, either by increasing the proportion of quercitron, or by prolonging the immersion. One advantage of this article over weld, is its scarcely colouring the white grounds when the heat of the bath has not been too much raised. Hence washing with cold water, and especially with hot water, suffices, without its passage through bran, and without exposure on the grass. From the difference between the temperatures which quercitron and weld require, the mixture of these two articles can produce no good effect. The addition of tartar increases the property possessed by quercitron, of not altering the white grounds. It makes the colour verge towards that green shade which causes weld to be sought after; but in this case the heat of the bath must be raised a little higher.

Bancroft describes a topical colour *(couleur d'application)*, which is obtained from quercitron. A strong decoction of quercitron is made, filtered, and evaporated at a gentle heat, and when it is reduced to less than one-half, it is allowed to cool to the temperature of the living body. After this, one-fourth of acetate of alumina is mixed with this liquid. The mixture is thickened with as much gum as is necessary to prevent its running during the impression, but not so much as to obstruct its penetrating the stuff. The colour

obtained by this application has neither as much intensity, nor as much permanence, as that procured by previously impregnating the stuff with the mordant. Both qualities may however be increased by a mixture of nitrate of copper and nitrate of lime.

Quercitron ought undoubtedly to be considered as a very useful substance in dyeing; yet the attempts which we know to have been made, with the precautions prescribed by Bancroft, especially in reference to the temperature of the bath, seem to us to prove, that the colour derived from it is inferior in permanence to that producible from weld. A purer and more lively colour may be obtained from quercitron, by adopting the process which Chaptal has given for fustic, (yellow wood).

CHAPTER IV.

Of Annotto (Rocou).

Annotto (in French *rocou* or *roucou*), is a somewhat dry and hard paste, brown without, and red within. It is usually imported in cakes (of two or three pounds weight), wrapped up in leaves of large reeds, packed in casks, from America, where it is prepared from the seeds of a certain tree, the *bixa orellana* of Linnæus.

We are indebted to Leblond for some accurate observations concerning the cultivation of the tree

whose seed serves for making annotto, the preparation to which these are subjected, and the means of improving this process.*

The pods of the tree being gathered, their seeds are taken out and bruised. They are then transferred to a vat, which is called the steeper, where they are mixed with as much water as covers them. Here the substance is left for several weeks, or even months; it is now squeezed through sieves placed above the steeper, that the water containing the colouring matter in suspension may return into the vat. The residuum is preserved under the leaves of the banana (pine apple) tree, till it becomes hot by fermentation. It is again subjected to the same operation, and this treatment is continued till no more colour remains.

The substance thus extracted is passed through sieves, in order to separate the remainder of the seeds, and the colour is allowed to subside. The precipitate is boiled in coppers till it be reduced to a consistent paste; it is then suffered to cool, and dried in the shade.

Instead of this long and painful labour, which occasions diseases by the putrefaction induced, and which affords a spoiled product, Leblond proposes, simply to wash the seeds of annotto till they be entirely deprived of their colour, which lies wholly on their surface, to precipitate the colour by means of vinegar or lemon juice, and

* Ann. de Chimie, tom. xlvii.

to boil up in the ordinary manner, or to drain in bags, as is practised with indigo.

The experiments which Vauquelin made on the seeds of annotto imported by Leblond, confirmed the efficacy of the process which he proposed, and the dyers have ascertained, that the annotto obtained in this manner was worth at least four times more than that of commerce; that, moreover, it was more easily employed; that it required less solvent; that it gave less trouble in the copper, and furnished a purer colour.

Annotto dissolves better and more readily in alcohol than in water; whence it is introduced into the yellow varnishes for communicating an orange tint.

The decoction of annotto in water has a strong peculiar odour, and a disagreeable taste. Its colour is yellowish-red, and it remains a little turbid. An alkaline solution renders it orange-yellow, clearer, and more agreeable; while a small quantity of a whitish substance is separated from it, which remains suspended in the liquid. If annotto be boiled in water along with an alkali, it dissolves much better than when alone, and the liquid has an orange hue.

The acids form with this liquor an orange-coloured precipitate, soluble in alkalies, which communicate to it a deep orange colour. The supernatant liquor retains only a pale yellow colour.

Solution of muriate of soda and muriate of ammonia produce no sensible change.

Solution of alum causes a considerable precipitate of a deeper orange hue than the deposite formed by the acids; the liquid retains an agreeable lemon colour, verging a little towards green.

Sulphate of iron forms an orange-brown precipitate; the liquor retains a very pale yellow colour.

Sulphate of copper affords a precipitate of a yellowish-brown, a little brighter than the preceding; the liquor preserves a greenish-yellow colour.

Solution of tin produces a lemon-yellow precipitate, which falls slowly.

When annotto is used, it is always mixed with alkali, which facilitates its solution, and gives it a colour inclining less to red. The annotto is cut in pieces, and boiled for some instants in a copper with its own weight of crude pearl ashes, provided the shade wanted do not require less alkali. The cloths may be thereafter dyed in this bath, either by these ingredients alone, or by adding others to modify the colour; but annotto is seldom used for woollen, because the colours which it gives are too fugitive, and may be obtained by more permanent dyes. Hellot employed it to dye a stuff prepared with alum and tartar; but the colour acquired had little permanence. It is almost solely used for silks.

For silks intended to become aurora and orange, it is sufficient to scour them at the rate of 20 per cent of soap. When they have been well cleansed, they are immersed in a bath prepared with water, to which is added a quantity of alkaline solution of annotto, more or less considerable, according to the shade that may be wanted. This bath should have a mean temperature, between that of tepid and boiling water.

When the silk has become uniform, one of the hanks is taken out, washed, and wrung, to see if the colour be sufficiently full; if it be not so, more solution of annotto is added, and the silk is turned again round the sticks. The solution keeps without alteration.

When the desired shade is obtained, nothing remains but to wash the silk, and give it two beetlings at the river, in order to free it from the redundant annotto, which would injure the lustre of the colour.

When raw silks are to be dyed, those naturally white are chosen, and dyed in the annotto bath, which should not be more than tepid, or even cold, in order that the alkali may not attack the gum of the silk, and deprive it of the elasticity which it is desirable for it to preserve.

What has been now said regards the silks to which the aurora shades are to be given; but to make an orange hue, which contains more red than the aurora, it is requisite, after dyeing with annotto, to redden the silks with vinegar, alum,

or lemon juice. The acid, by saturating the alkali employed for dissolving the annotto, destroys the shade of yellow that the alkali had given, and restores it to its natural colour, which inclines a good deal to red.

For the deep shades, the practice at Paris, as Macquer informs us, is to pass the silks through alum; and if the colour be not red enough, they are passed through a faint bath of brazil wood. At Lyons, the dyers who use carthamus sometimes employ old baths of this ingredient for dipping the deep oranges.

When the orange hues have been reddened by alum, they must be washed at the river; but it is not necessary to beetle them, unless the colour turns out too red.

Shades may be obtained also, by a single operation, which retain a reddish tint, employing for the annotto bath a less proportion of alkali than has been pointed out.

Guhliche recommends to avoid heat in the preparation of annotto. He directs it to be placed in a glass vessel, or in a glazed earthen one, to cover it with a solution of pure alkali, to leave the mixture at rest for 24 hours, to decant the liquor, filter it, and add water repeatedly to the residuum, leaving the mixture, each time, at rest for two or three days, till the water is no longer coloured; to mix all these liquors, and preserve the whole for use in a well-stopped vessel.

He macerates the silk for 12 hours in a solution of alum, at the rate of an eighth of this salt for one part of silk, or in a water rendered acidulous by the aceto-citric acid above described; and he wrings it well on its coming out of this bath.

Silk thus prepared is put into the annotto bath, quite cold. It is kept in agitation there till it has taken the shade sought for; or the liquor may be maintained at a heat far below ebullition. On being taken out of the bath, the silk is to be washed, and dried in the shade.

For clearer hues, a liquor less charged with colour is taken; and a little of the acid liquid which has served for the mordant may be added, or the dyed silk may be passed through the acidulous water.

If the last shades are to have less of the orange, and to approach the colour of nankeen, a little of the solution of nut-galls, in white wine, is to be added.

To give an orange colour to cotton, Wilson directs us to bruise the annotto when it is moistened, to boil it in water with double its weight of alkali, to let it settle for half an hour, to pass the clear liquor into a heated vessel, and to immerse the cotton in it, when it will take an orange colour. A hot solution of tartar is to be then poured into the bath, so as to make it feebly acid; the cotton hanks are turned through it on the skein sticks, or wound on the winch when in the

piece. The colour becomes thereby more lively, and fixes better. A slight washing is afterwards given to the cotton, and it is dried in a stove.

We have seen the following preparation employed for cotton velvet. One part of quicklime, one of potash, two of soda. Of these a ley is formed, in which one part of annotto is dissolved; and the mixture is boiled for an hour and a half. This bath affords the liveliest and most brilliant auroras. The buff (chamois) fugitive dye is also obtained with this solution. For this purpose only a little is wanted; but we must never forget, that the colours arising from annotto are all fugitive. (Note OO.)

CHAPTER V.

Of Saw-wort (Sarrette), *Serratula Tinctoria, and several other Articles capable of dyeing Yellow.*

The *serratula tinctoria*, saw-wort, is a plant which grows abundantly in woods and meadows. It affords, without mordants, a greenish-yellow colour, which wants permanence; but by means of alum employed in a particular *bouillon*, or put into the bath with the saw-wort itself, this plant gives a permanent and agreeable colour. According to Poerner, the mordants that suit it best are alum and sulphate of lime. It is needless to state, that the last article forms a deeper shade, and that the hue may be varied also by the pro-

portion of mordant and of saw-wort. Scheffer directs us to prepare the wool with alum and a 12th of tartar; and adds, that if prepared with 3-16ths of solution of tin, and as much tartar, it takes a much livelier colour than the preceding.

Dyer's broom, or dyer's weed, (*genista tinctoria*, the *genestrole* of the French), which grows abundantly in dry and hilly grounds, yields a yellow colour, which cannot be compared in beauty with that of weld and saw-wort, but it acquires sufficient permanence by means of mordants. Those which may be employed with most advantage, either for the preparation of the cloth or in the bath, are tartar, alum, and sulphate of lime.

Chamomile, (*camomilla matricaria*), a plant well enough known, affords a pretty agreeable faint yellow colour, but it is not fast. The mordants fix it a little; of which the most useful are alum, tartar, and sulphate of lime.

According to Scheffer, a beautiful yellow is given to silk with the decoction of this plant, in which some solution of tin, saturated with tartar, is poured, drop by drop, till the colour shall become sufficiently yellow. For dyeing the silk, this is kept hot without boiling. He recommends the employment of pure water, which does not precipitate the solution of tin.

Fenugreek (*trigonella fœnugræcum*) produces seeds, which, when ground, are capable of dyeing a pretty fast pale yellow. The mordants

which succeed best with this substance, are alum, and muriate of soda.

The *turmeric (curcuma longa, terra merita* of the French,) is a root imported from the East Indies. It has been cultivated at Tobago; and some of it sent thence was superior to that of commerce, both in the thickness of its roots and the abundance of its colouring matter. This substance is very rich in colour, and no other affords so brilliant an orange-yellow. But it has no permanence, nor can mordants give a sufficient degree of it. Muriate of soda, and muriate of ammonia, are the substances which best fix this colour, but they deepen it, and make it incline to brown. Some persons recommend a small quantity of muriatic acid. For employing this root, it must be reduced to powder. It is sometimes used for giving yellows made with weld a gold cast, as also for giving an orange hue to scarlet; but the shade arising from the turmeric is not long of disappearing in the air.

Fustet, Venus's sumach *(rhus cotinus)*, is a wood possessing a mixed colour of orange and green. Its fibres have a play of colours, (*sont chatoyantes*).

This wood affords a fine orange colour which has no permanence; hence it is not employed alone, but is used by mixing it with other colouring substances, and particularly with cochineal, to give the scarlet a flame colour, and for pomegranates, *jujubes*, *langoustes*, oranges, *jonquilles*,

golden colours, buffs, and, in general, for all the colours with which we wish to associate more or less of an orange hue. The advantage to be found in the use of this substance, consists in its colour becoming pale without change of shade; but when it is joined with other colours, it is more durable than when alone.

The *grain of Avignon*, French berries, the berry of the *rhamnus infectorius*, (*épine cormier* in French), which is gathered before it is ripe, affords a pretty fine yellow, but it has no permanence. It may be used by preparing the cloth in the same way as for dyeing with weld. As this berry is rich in colour, it is often substituted for weld in calico-printing, although it is inferior in quality.

The leaves of willow are mentioned by Scheffer, as capable of yielding a fine yellow colour to wool, silk, and linen. Bergman says, that the leaves of the laurel willow should be preferred (*salix pentandra*), and that the leaves of common willow afford a colour, most part of which is soon discharged by the sun.

Scheffer directs the wool to be left for a night in a cold solution of one-fifth of alum, and one-sixteenth of tartar. The *bouillon* is made from the leaves picked up towards the end of August or the beginning of September, which have been dried in a shady, but well aired situation. Of these a suitable quantity is to be taken, and boiled for half an hour. 1-256th part of white potash is added

to it, to render the colour livelier and deeper, after which the bath is passed through a sieve. It is kept in a state approaching to ebullition, and the wool is dyed in it, till it has assumed the wished-for colour. He prescribes the same process for silk and linen, augmenting merely the proportion of alum by a sixteenth. According to Bergman's account, Alströemer observed, that the colour was rendered richer by macerating the flax with a larger quantity of alum, and wringing and drying it before dyeing; and that for the complete extraction of the colouring matter, it was requisite to increase the quantity of potash.

The bark, and particularly the young branches (shoots) of the Italian poplar, and some other species of poplar, give to wool, according to d'Ambourney, a fine durable yellow colour, especially when the wool has been prepared with solution of tin. Nearly seven parts in weight of this wood are required to dye one of wool.

The seeds of purple trefoil (*trifolium pratense purpureum majus Raii*) are employed in Switzerland and in England for dyeing. Vogler has tried to determine what colours can be procured from it, and he found, that the bath of this seed, with solution of potash, afforded a very deep yellow; with sulphuric acid, a clear yellow; with solutions of alum and tin, a lemon yellow; with sulphate of copper, a greenish-yellow. Woods impregnated with these mordants, and boiled for some

minutes in the bath of purple trefoil seed, are found to be dyed very durably different shades of the colours just enumerated. The yellows form a fine green with indigo. Luzern *(medicago sativa)* afforded the same results.*

Dizé made comparative experiments with the trefoil and weld.† It thence follows, that the trefoil seed gives to wool a beautiful orange-yellow, and to silk a greenish-yellow; that solution of tin cannot be employed for this dye, because it requires an aluming; and, lastly, that blue applied to the yellow derived from trefoil seed, forms a less beautiful and duller green than that for which weld had been used.

Common Canada golden rod *(solidago canadensis)* had already been recommended by Hellot. Gaad said, in the Memoirs of Stockholm, that this plant afforded a yellow colour, superior even to weld, and that it was far preferable to dyer's broom. As no use has been made of it, however, and as it is a plant easily cultivated, Succow subjected it to new trials.‡ As his experiments with reagents presented nothing peculiar, they may be omitted. A decoction of the stalks of this plant, to which the author added a considerable proportion of alum, gave to a pattern of cloth, which had received no preparation,

* Annales de Chimie, tom. iii.
† Journ. de Physique, 1789.
‡ Crell, Ann. Chem. 1787.

a very lively straw-yellow colour; to another pattern, prepared with sulphate of iron, a greenish-yellow colour; and to a third pattern, which had been prepared with alum, a very pure and lively lemon-yellow hue.

The flowers of French Marygold *(tagetes patula)*, separated from their calyx, were submitted to the same trials. The cloth, without preparation, took in the decoction of these flowers a deep yellow colour; prepared with sulphate of iron, a greenish colour, which, by continued ebullition, became very deep; and, lastly, cloth prepared with alum assumed a very lively yellow colour, inclining a little to green. If a little alum be added to the bath before immersing the stuff in it, a very beautiful and lively yellow is obtained. It has more lustre than even the colour procured from the Canada golden rod.

There are many other substances which may be employed for dyeing yellow, and which afford shades of greater or less permanence and beauty; such are, the bark of the *(épine vinette)* barberry, the flower of wild chervil or cow-weed, the common stinging nettle, the root of patience-dock, the bark of the ash, the leaves of the almond tree, of the peach tree, pear tree, the flowers of the common furze, &c. In Part I. it was shewn that nitric acid could also be employed for giving a yellow colour.

White flowers, according to the observation of Lewis, give the water with which they are boiled a somewhat deep yellow colour. The acids,

alkalies, and the salts, act upon this colour as on those of other vegetable substances. *

It appears, that the substances which may be used for dyeing yellow are very numerous. They differ from each other in the quantity of colouring matter, in their dye being more or less plain, lively, or of an orange or greenish cast, in their degree of permanence, and in their price. By comparing these particulars, a determination is to be made as to their choice, according to the quality of the stuff, the colour that is wanted, and the concomitant circumstances.

In general, the alkalies render the colour of these substances deeper and more of an orange cast: they facilitate the extraction of the colouring matter; and it is only by their means that it is obtained from annotto; but they also favour its destruction. Sulphate of lime, muriate of soda, muriate of ammonia, deepen the colour of yellow substances; the acids brighten them, and make them more permanent. Alum and the solution of tin render them clearer, and at the same time more brilliant and durable.

Few of the yellows produced from vegetable substances can acquire upon cotton permanence comparable to that of the colours producible from madder; and they never acquire this quality without losing their lustre. When a colour rather fast than brilliant is wanted, the cotton is coloured with oxide of iron, by inpregnating it with

* The Chemical Works of Caspar Neuman.

any of the various solutions of this metal. The processes employed for this dye are very numerous, and their shades may obviously be greatly multiplied, by varying the state of oxidation of the metal, or the nature of the acid which holds it in solution; as also by slight changes in the proportions of the materials, and in the manipulations.

In order to obtain a deep colour, Chaptal treads the cotton in a solution of sulphate of iron, marking from 12° to 15° Baumé. He squeezes it very slightly but equably. As soon as the whole portion (lot) is dipped, it is repassed, hank by hank, through the same solution, and immediately afterwards through a solution of potash, marking the same number of degrees. The colour of the cotton becomes of a dirty blue-green, which changes in a few minutes to an agreeable golden yellow. At each dipping the vessel into which the cottons are plunged must be emptied, in order that the colour may be equal and uniform.

For a pale and very soft yellow, he treads the cotton in a solution of sulphate of iron, marking three degrees, and repasses it as in the preceding process. On the other hand, he prepares a liquor with solution of potash, marking from two to three degrees, to which he adds solution of alum till he observes that the flocks are no longer dissolved. He impregnates the cotton with this liquid, and renews it for each dip. The cotton is dyed of a very agreeable yellow.

When the colours are not sufficiently deep, the cotton may be repassed through stronger solutions.

Chaptal recommends, for making the colours evenly, to pass at once no more than ¼ kilogramme of cotton, to employ weak solutions of sulphate of iron, to dip the cotton first in a solution of potash, then in one of sulphate of iron, repeating these alternate dips as often as shall be requisite to arrive at the desired shade, and to use the greatest care in impregnating and squeezing the cotton equably.

A fresh-butter yellow is produced, by passing the cotton through slightly oxidized acetate of iron, mixed with nitrate of iron, which may be made to incline more to red, the greater the proportion of the latter salt.

With nitrate of iron alone, diluted with water, a pretty clear yellow may be had, which rises quickly. If the cotton be impregnated with nitrate of iron little diluted, allowed to dry, and then washed, it retains a very deep tint, similar to that of rust.

The rust-yellow, which is printed on cloth, is made with two parts of sulphate of iron, and one part of acetate of lead. By mixing with this, different proportions of highly oxidized oxide of iron, shades bordering on red may be procured.

Cotton dyed by these processes takes very different colours in the dye-baths. That which received a faint yellow colour by the process of

Chaptal, becomes of a walnut hue in the decoction of galls. When the colour is deeper, it becomes mouse-grey; with tan, or quercitron, it affords a yellow. When passed through a decoction of equal parts of nut-galls, sumach, logwood, and weld, the cotton becomes of a dirty grey-white. When dried, and passed through a strong solution of sulphate of iron, it assumes the bluish-grey colour, which is called *œil de roi.* (NOTE OO.)

SECTION V.

OF DUN, ROOT, OR FAWN COLOUR, (FAUVE).

Only some of the substances employed for producing dun colours will be treated of, because their number is too great to be examined in detail; and they resemble one another sufficiently in their characters to render the observations made on a few applicable to the whole.

CHAPTER I.

Of Walnut Peels.

It is known that walnut peels are white interiorly, but when exposed to the air, they become brown, and then black. Hence, if the skin has been impregnated with its juice, it soon assumes a brown, and almost black colour.

If the internal part of fresh walnut peels be plunged into oxygenated muriatic acid, it becomes brown in like manner.

The filtered decoction takes a deep brown colour in the air; it yields pellicles on evapora-

tion, which, when separated, well washed, and dried, are nearly black. The liquor freed from these pellicles yields a brown extract, which may be completely redissolved in water; but by a new evaporation it still affords pellicles similar to the first.

These pellicles, which are formed in several other evaporations, are derived from the colouring substance, whose properties have been changed from an increase in the proportion of carbon, by an agency which has been elsewhere explained.

Alcohol precipitates the colouring matter of the decoction of walnut peels in the form of a brown substance, which may be redissolved in water.

The solution of potash produces at first no sensible change in the decoction of walnut peels; but by degrees it becomes a little turbid, and its colour deepens.

Muriatic acid brightens up its colour, turning it yellow; there is formed a small quantity of a brown precipitate, and the liquor remains of a clear yellow.

Solution of tin produces an abundant precipitate in the decoction of a dun ash colour; the liquor retains only a faint yellow hue.

Solution of alum disturbed the liquor slightly; a very small deposite was formed of a dun brown. The liquor preserved a clearer colour, but still dun.

Solution of sulphate of copper disturbed the liquor but very slowly; a scanty green-brown precipitate was formed. The supernatant liquid remained green.

Acetate of lead speedily formed an abundant deposite of a deep dun colour.

Solution of sulphate of iron rendered the colour much deeper, and even black. On diluting it with water, it passed through brown to greenish-dun, but it let fall no deposite.

Solution of pure sulphate of zinc disturbed the liquor but slightly, rendering the colour thereby deeper.

The decoction of walnut root presented nearly the same properties. On separating the bark from the ligneous substance of this root, the former yielded in equal weight a liquor much more charged with colour. The bark of the wood of walnut also exhibited properties approaching to those of walnut peels, but its decoction formed a blackish precipitate with sulphate of iron.

Walnut peels exercise a lively action on oxide of iron, dissolving it, and forming a liquor as black as ink. If boiled along with clean filings they do not attack them, but if left exposed to the air, the liquor becomes soon black.

The colouring matter of walnut peels has a great disposition to combine with wool. It gives it a very durable walnut or dun colour, and mordants appear to add little to its permanence, but they may vary its shades, and give them more

lustre. By preparing the stuff with alum, a richer and livelier colour may be obtained.

Walnut peels are of excellent use, because they give agreeable and very durable shades, and being employed without any mordant, they preserve the softness of the wool, and require but one simple and not expensive operation. Walnut peels are gathered when the nuts are entirely ripe. Large casks or tubs are filled with them, and a sufficiency of water is poured on them to cover their surface. In this state they may be kept a year and upwards. At the Gobelins, where a very extensive and varied use is made of this ingredient, it is kept for two years before it is employed. It is found then to furnish much more colour. It has a very unpleasant putrid odour.

The peels may also be used which are taken from the nuts before they are ripe; but they do not keep so long.

When it is wished to dye with walnut peels, they are boiled for a full quarter of an hour in a copper, in quantity proportioned to the amount of stuff, and to the depth of shade that is desired. For cloths, the deepest shades are usually begun with, finishing with the lighter ones; but for woollen yarn, it is commonly the clearest shades that we begin with, and the deepest shades are made at the end, with the addition of husks for each parcel. The woollen cloth and yarn ought to be simply moistened with tepid water, before being plunged in the copper, in which they are

turned about with care till they have assumed the desired shade, unless a preliminary aluming be given.

The root of walnut gives the same shades, but for this effect the quantity must be increased. It must be reduced to chips; and it is proper to enclose it in a bag, to prevent the little chips from sticking to the stuff. The colour becomes often unevenly with the formation of spots. To obviate this inconvenience, the fire must be tempered at the beginning, that the colouring particles may be equably distributed through the bath, in proportion as they are extracted from the root. If some parts be unequally dyed, as the colour is fast, there is no method of remedying this accident, except to reserve the stuff for deeper colours.

CHAPTER II.

Of Sumach, and some other Substances capable of affording a Dun Colour.

Common sumach (*rhus coriaria*), is a shrub which grows naturally in Syria, Palestine, Spain and Portugal.

It is diligently cultivated in Spain and Portugal. The shoots are cut down to the root every year, then dried, that they may be ground to powder in a mill. This powder is employed by dyers and tanners. The name of *rédoul* or

roudou is given to the sumach cultivated in the neighbourhood of Montpellier.

The infusion of sumach is of a dun colour, bordering on green. It speedily becomes green in the air. When it is recent, the solution of potash produces little change on it. The acids clear up its colour, and render it yellow. Solution of alum makes it turbid, producing a scanty yellow precipitate, while the liquor remains yellow.

Acetate of lead forms instantly an abundant yellowish precipitate, which takes a brown colour on its surface; the liquor remains of a clear yellow.

Sulphate of copper affords a copious yellowish-green precipitate, which, after some hours, changes to a brown-green. The liquor remained clear, and a little yellow.

Sulphate of zinc of commerce rendered the liquor turbid, blackening it, and forming a deep blue precipitate.

Pure sulphate of zinc deepened the colour much less; only a slight dun deposite verging on brown took place.

Muriate of soda produced no sensible change at first; but after some hours, the liquor was a little turbid, and its colour had become somewhat clearer.

Sumach acts like nut-galls on solution of silver, whose metal it reduces; a result promoted by the action of light. We have already dwelt at sufficient length on the explanation of this phe-

nomenon, as well as the general properties of astringents.

Sumach affords, of itself, a dun colour bordering on green; but it communicates to cotton stuffs several very permanent colours when they are combined with mordants.

Thus, as we have already stated, it yields a black with acetate of iron, if this has been printed on in a state of concentration, but shades of grey if it has been diluted with water. With acetate of alumina it gives a durable yellow, which retains somewhat of a greenish shade; hence, if into the same pattern, yellow, grey, and black colours are to be introduced, they may all three be given by sumach.

To dye with this substance, the water must be heated to about 50° Reaumur, the sumach is then to be thrown in, and the cloths immediately introduced, leaving them immersed only 15 or 20 minutes, with a slight elevation of the heat of the bath. If the heat be too much raised, and if the cloths be left too long in the boiler, the colours will become weaker instead of stronger; and even, in a little time, those that have iron for their mordant disappear almost altogether. This effect, which occurs in a less remarkable degree with many other dyes, requires us to catch the very instant for withdrawing the cloths, when the colours are sufficiently raised. To procure an evenly colour, only a small number of pieces should be dyed at a time.

Cloths dyed with sumach resume a fine white with difficulty, and are little improved by exposure on the grass. More effect is produced by passing them through water, sharpened with so little sulphuric acid as to make it just perceptibly sour. By this means the greys lose the russet tint which they have on coming out of the boiler, and become agreeable. Blacks thereby acquire a great deal of lustre.

We have said, in treating of greys, that by alternately passing the cotton through a decoction of sumach, much diluted with water, and an equally dilute solution of iron, very agreeable shades of grey are obtained, whose intensity depends on the concentration of the bath, and the number of times that the operations are repeated. In general, to dye equably in this way, the colours must be slowly brought up, beginning with very feeble baths, passing repeatedly through each of them, and gradually increasing their strength when deep shades are wanted.

By finishing with the solution of sulphate of iron, the cotton has not that russet hue which it takes when sumach is last used, which it becomes necessary to remove with the acidulated water.

With concentrated solutions of sumach and sulphate of iron, the cotton assumes a black colour when it has been turned 3 or 4 times through each of them; and if, on issuing for the last time from the sulphate of iron, it be passed through a tepid decoction of logwood, to which a little acetate of copper is added, the black becomes

brilliant and sufficiently fast. The cotton is softened and the black heightened, by passing it through hot water into which a little oil has been poured.

If, in dyeing grey, the decoction of logwood be mixed with that of sumach, the grey becomes slate coloured; if after this it be passed through a very dilute decoction of weld, mingled with alum, it inclines towards pearl-grey.

By substituting nut-galls for sumach, other shades are obtained.

Cotton thus treated with the decoction of logwood and with sulphate of iron, affords slate-greys of little permanence.

Decoction of quercitron produces American grey; and if a little alum and muriate of tin be mixed with it, instead of that colour, an American green is produced.

With yellow wood (fustic), alder bark, &c. other colours are obtained. By thus varying the colouring matters, and making use of sulphate of iron and alum, or muriate of tin, and combining variously the order and number of the operations, as well as the concentration of the baths, a great many shades may be obtained on cotton, which are generally pretty fast.

This manner of dyeing, by passing alternately through the mordant and the colouring matter, is of advantage for procuring uniform colours; and it further presents great facilities for attaining the wished-for shade, and for diversifying those produced.

Birch tree bark, *betula alba*, (*l'aune* of Berthollet), affords a decoction of a clear dun hue, which becomes speedily turbid, and brown in the air. It forms with solution of alum a pretty copious yellow precipitate; and with solution of tin, an abundant precipitate of a clear yellow. It blackens the solutions of iron, forming with them a tolerably copious precipitate; hence it contains much of the astringent principle. It dissolves a large quantity of the oxide of iron; thence the use made of it in the black vats, destined for dyeing (linen) yarns. It does not, however, possess the property of dissolving the oxide of iron in the same degree with the decoction of walnut peels.

Much use is made for ordinary stuffs in the East, of the leaves of a shrub called Henna (*Hhenne*), which is of the family of Salicaria. It was known to the ancients by the name of Ciprus, and was employed for dyeing the envelopes of mummies, in which its colour is still observable.

The leaves of this shrub, now cultivated in Egypt, are bruised, after being hastily dried. A paste is then made of them, which is used for dyeing the nails and the palms of the hands of a reddish dun, (a tawny hue).

The powder of these leaves has an olive colour; it yields by boiling with water a very deep orange dun, very rich in colouring matter.

Almost all vegetables contain, especially in their bark, more or less colouring matter, capable of affording dun hues, inclining to yellow, brown, red, or green. These colouring matters present

greater or less differences among each other, in reference to their quantity and quality; they further vary according to climate and the age of the vegetable. A great diversity of shades, therefore, may be procured, by modifying the dun natural to the vegetables, by means of different mordants. This has been accomplished by Siefferts,* and particularly by D'Ambourney.† Thus in a great many experiments which the latter made, employing the parts of different vegetables, and using different mordants, the colours which he produced were, for the most part, between yellow and brown, such as *carmelites*, olives, cinnamons, and marrones.

The decoction of the greater part of vegetables, and especially of barks, affords a colour differing only in shade, and exhibits with reagents nearly the same characters: it forms a yellow precipitate more or less deep with alum, and a clearer colour with solution of tin. It acts on solutions of iron as an astringent. The decoction of walnut peels, however, produces a peculiar effect with solutions of iron; it assumes a very deep colour, but no precipitate is formed even after two or three days. Their decoction, as well as that of walnut tree bark, has a powerful action on oxide of iron; it saturates it, forming a black liquor; and even if filings of iron be put into this decoction exposed

* Versuché mit einheinmischen farbe materien.

† Recueil des procédés et d'expériences sur les teintures solides, que nos végétaux indigènes communiquent aux laines et aux lainages.

to the air, in two or three days it forms a black liquor by means of the oxygen which it attracts from the atmosphere. But if a decoction to which solution of sulphate of iron has been added, be boiled, an abundant black deposite instantly falls. It is only, therefore, in a trifling circumstance that walnut peels, as well as walnut tree bark, differ from the other substances which yield a dun colour; yet its extractive matter possesses in particular the property of becoming black by the action of the air, and the pellicles formed when it is evaporated, assume in a very marked degree the appearances of a carbonized substance.

If the yellow colour produced by several vegetable substances be compared with the dun which most of them afford, a close relation will be found between these colours. There are even some which may be referred equally to yellow and to dun. There are duns which, by means of alum and solution of tin, pass to yellow, and the yellow is very fast. The following distinction may be laid down. The yellows are in general more changeable, more apt to yield fugitive colours; for which reason the yellow colours must be fixed by means of mordants, whereas the most part of dun coloured substances afford by themselves a pretty permanent colour.

As the dun shades obtained from different substances vary to a great extent, sometimes several of these substances are blended in order to obtain a peculiar colour, and that in different proportions. Other ingredients are also mixed

with them, to modify their colour and to render it faster.

Among these substances, there is still one which deserves attention; this is, sandal or saunders wood.

Three kinds of sandal wood are distinguished; the white sandal, the yellow, and the red. The last alone is employed in dyeing. It is a solid, compact, heavy wood, imported from the coast of Coromandel, which becomes brown on remaining exposed to the air. It is usually employed in the state of a very fine powder. It affords a colour dun, brown, and verging on red. By itself it furnishes little colour, and it is said to harden the wool. But its colouring matter dissolves better when mixed with other substances, such as walnut peels, sumach, nut-galls. Besides, the colour which it gives is permanent, and modifies advantageously the colours of the substances with which it is mixed.

Vogler having observed, that dilute alcohol or proof spirit dissolved the colouring matter of sandal wood much better than water, made use of this solution, either by itself, or mixed with from 7 to 8 parts of water, for dyeing patterns of wool, silk, cotton, and linen, which he had prepared beforehand, by impregnating them with solution of tin, washing and drying them. These patterns took all a poppy-red colour. Patterns prepared likewise with alum, took a saturated scarlet colour; prepared with sulphate of copper, a beautiful clear crimson hue; prepared with sulphate of iron, a

fine deep violet colour.* He dyed cold with the spirituous liquor; but employed a slight ebullition for that which was mixed with water. This mixture takes place without the transparency being disturbed.

Soot is also employed for giving to wool a dun or brown colour of greater or less depth, according to the proportions of this ingredient; but soot gives only a fugitive colour, because it simply adheres to the wool, instead of combining with it. It hardens it, and leaves a bad smell. It is employed, however, in some respectable manufactories, for browning certain colours; undoubtedly, because shades are thereby obtained, which could be got with difficulty by other means.

* Crell's Annals, 1790.

SECTION VI.

OF COMPOUND COLOURS.

Simple colours form, by their mixture, compound colours; and if the effects of the colouring particles did not vary, according to the combinations which they form, and the actions exercised on them by the different substances present in a dyeing bath, we might determine with precision the shade that ought to result from the mixture of two other colours, or of the ingredients which afford these colours separately: but the chemical action of the mordants, and of the liquor of the dye bath, often changes the results; theory, however, may always predict these effects to a certain degree.

It is not the colour peculiar to the colouring matters which is to be considered as the constituent part of compound colours, but that which they must assume with a certain mordant, and in a certain dye bath. Hence, our attention ought to be principally fixed on the effects of the chemical agents employed.

It is in this department of dyeing that the intelligence of the operator may be most useful,

by enabling him to vary his processes, and to arrive at the proposed end by the simplest, shortest, and least expensive way.

The processes for compound colours are very numerous. We shall mention only those which most merit attention, and shall establish the principles on which they ought to be conducted by particular examples. Several of the processes described in the course of this work, afford compound colours. We shall now consider, in an especial manner, this part of the art of dyeing.

CHAPTER I.

Of the Mixture of Blue and Yellow, or Green.

Many different plants are capable of affording green colours; such as, the field broom grass (*bromus secalinus*); the green berries of the berry-bearing alder (*rhamnus frangula*); wild chervil (*chærophyllum silvestre*); purple clover (*trifolium pratense*); common reed (*arundo phragmites*); but these colours have no permanence.

D'Ambourney says, however, that he has extracted a durable green from the fermented juice of the berries of the *rhamnus frangula*; he prepared the cloth with tartar, nitric solution of bismuth, and muriate of soda; and he added to the fermented and tepid juice of these berries a little acetate of lead. The cloth took, in this bath,

an intermediate shade between parrot-green and grass-green.

Poivre, and some other writers, had announced, that there existed in different parts of India a green fecula, or a kind of green indigo, which would be precious to the dyer; but some trials of Bancroft seem to prove, that it was merely common indigo united to a yellow substance.

By mixture of blue and yellow, dyers form green, which is distinguished by a great number of shades. Address and experience are required for obtaining this colour uniform, and without spots, especially in the light shades.

The green may be formed by beginning the dyeing either with yellow or blue; but the first method has some disadvantages, for the blue soils the linen, and a portion of the yellow dissolving in the vat, alters, or makes it green. The second method is preferred for woollen stuffs.

The pastel vat is usually employed; but for some kinds of green, solution of indigo in sulphuric acid is used; in which case, the blue and yellow are separately dyed, or indeed all the ingredients may be mixed for dyeing at one operation. Finally, solutions of copper, with yellow substances, are had recourse to. We shall take a view of these different processes.

The blue ground which is given by the vat, should be proportioned to the kind of green that is wanted. Thus, for *verd canard*, the green like that of drake's neck, a deep blue is required;

for parrot-green, a sky-blue ground; for *verd naissant*, nascent green, one of white-blue (*bleu blanchi*).

When the cloths have undergone this operation, they are washed at the fulling-mill, and a *bouillon* is given them as in ordinary welding; but for the lighter shades, the proportion of salts is diminished. More frequently the *bouillon* for cloths intended for light shades is first given, and after taking them out, some tartar and alum are added; and this practice is pursued until we come to the cloths destined for the deepest shades, by the progressive addition of more tartar and alum.

The welding is conducted as for yellow; but a greater quantity of weld is employed, unless light colours alone are to be dyed, for which the proportion ought on the contrary to be less. Usually a succession of shades is dyed at the same time, from the deepest to the lightest; beginning with the deepest, and proceeding to the lightest. Between each dip (*mise*), which lasts half an hour, or three quarters, water is added to the bath. Some dyers pass each parcel twice through each bath. They begin the first time with the deep shades, and the second with the light ones. In this case, each parcel should remain a shorter time in the bath. Care must be taken not to boil the bath for very light shades.

A browning is given to the very deep greens, with logwood and a little sulphate of iron.

It is still more difficult in silk than in cloth to prevent the green from being spotted and variegated. Silk intended for greens is boiled as for the ordinary colours; for light shades, however, it should be boiled thoroughly as for blue.

Silk is not first dyed blue like cloth; but after a strong aluming, it is washed slightly in the river, and distributed into small hanks, that it may take the dye equably; after which it is turned carefully round the sticks, through a bath of weld. When it is thought that the ground is sufficiently deep, a pattern is tried in the vat, to see if the colour has the wished-for tone; if it has not ground enough, decoction of weld is added; and when it is ascertained that the yellow has reached the proper degree, the silk is withdrawn from the bath, and passed through the vat as for blue.

To render the colour deeper, and at the same time to vary its tone, there are added to the yellow bath, when the weld has been taken out, juice of brazil wood, decoction of fustet, and annotto. For the very light shades, such as apple-green and celadon-green, a much weaker ground is given than for the other colours. For the light shades, if not for sea-green, it is preferable to dye yellow in baths which have already been used, but in which there is no brazil wood or fustet, because the silk, perfectly alumed, dyes too rapidly in fresh baths, and is thence subject to take an unevenly colour.

For dyeing green in raw silks, those naturally white are selected as for yellow; and after being well soaked, they are alumed, and treated in the same way as the other silks.

When the blue vat is used for dyeing green, saw-wort may be employed instead of weld. It is even preferable, because the colour which it gives naturally inclines to green. Dyers' broom is also employed, and sometimes these two ingredients are mingled. Other substances which dye yellow may also be used, and a variety of shades may thus be procured.

The green obtained by means of solution of indigo in sulphuric acid, is known by the name of Saxon green. It has more brightness, but less permanence, than that just described. This process was first practised in Saxony, and government caused a description of it to be published in 1750.* According to this description, the cloth must be boiled with alum and tartar for half an hour; it is then to be withdrawn, and aired, without washing. The bath is refreshed (with cold water), the solution of indigo is well mixed with it, pouring in at first only the half; the cloth is then let down, and turned rapidly through it, without boiling, for five or six minutes. It is lifted out, that the remainder of the solution may be poured in, which should be mixed with great care. The cloth being slightly boiled for seven

* Manière de teindre un drap blanc en vert, nommé vert de Saxe.

or eight minutes, is taken out and cooled. The bath is emptied to about 3-4ths, more or less, according to the shade of green that is wanted, and is filled up with a decoction of fustic; and when this bath is very hot, the cloth which had been dyed blue, and cooled, is passed through it, till it has acquired the wished-for shade. Cloth dyed blue in the bath with alum and tartar, has a less brilliant but more durable colour than when it is made blue without this mixture.

Experience has taught that this process may be executed in a more expeditious, and even more certain manner. The cloth is boiled as for welding, and then washed. Some fustic, reduced into chips, and enclosed in a bag, is put into the same bath. It is boiled an hour and a half; it is lifted up, and the bath is refreshed, so that the hand can be kept in it; about 0.6 of a kilogramme of solution of indigo is poured in for every piece of cloth 22 metres long (about 24 yards) which is to be dyed; this is to be turned through quickly at first, and afterwards slowly, and the cloth is lifted out before the bath boils.

It is a proper practice to pour in, at first, only 2-3ds of the solution, to lift up the cloth after two or three turns, and then to add the remaining third. The colour is thus rendered more uniform. If the colour seems not to take well, a little calcined alum, reduced to powder, is added. Saxon apple-green is dyed in the bath which has served for Saxon green, after a third or a half of it has been thrown out, and after it

has been refreshed. The cloth is turned through it, till it approaches to ebullition.

It is easy to see that a great variety of greens may be produced, not only according to the proportions of the indigo and yellow dyes employed, but according to the nature of the yellow substance. For obtaining a decided green, however, fustic is preferred to the other colouring substances, because its colour is less affected by sulphuric acid, which clears up and impairs considerably that of the other substances.

In order to avoid this effect with the quercitron, Bancroft directs us to dye the stuff at first blue, to rinse it well in water, and give it afterwards a *bouillon* composed of three parts of washed chalk, and 10 or 12 of alum, for 100 of cloth. It is to be boiled for an hour. Then, without changing the bath, 10 or 12 parts of quercitron are introduced, and the dyeing is continued. At the end of a quarter of an hour, one part of chalk is added, and this addition is repeated at intervals of six or eight minutes, till a fine green colour is brought out.

Bancroft recommends, on several occasions, and other authors do the same, to add carbonate of lime to the sulphate of alumina (alum), for saturating the excess of acid in the latter; but it is merely the decomposition of a portion of the alum which is thereby produced, and this decomposition is complete, if the proportion of carbonate of lime be sufficient. The carbonic acid is expelled; the alumina precipitates, retain-

ing a little sulphuric acid; and the sulphate of lime falls down in part, and is in part held in solution, according to the quantity of water. The effect which lime, or carbonate of lime, produces on alum, must not be confounded with that occasioned by potash or soda.

If a solution of alkali, deprived of carbonic acid, or even in the state of a carbonate, be poured, by portions, into a solution of alum, the small precipitate which occurs on the contact of the (alkaline) liquid is immediately redissolved; and it is only when the acidity is nearly saturated by the alkali, that the precipitate ceases to disappear. But the combination, even when neutral, retains a portion of alumina; and when the precipitate has become permanent, it may be redissolved by a superabundance of alkali. It is obvious, therefore, that alkali can enter into combination with the sulphate of alumina (alum), and that a change may thus be introduced into it, favourable to the operations of dyeing; whereas lime, and carbonate of lime, produce the immediate separation and precipitation of the alumina.

The sulphuric acid may be abstracted in the process under discussion, by boiling the stuff that has been dyed Saxon blue, with carbonate of lime, before subjecting it to the *bouillon* of alum.

It is mentioned as a fault in Saxon blue, that it has a greenish cast, proceeding probably from the slight alteration that sulphuric acid produces on the particles of indigo: it likewise, as well as

Saxon green, is said to have less durability than the blues and greens obtained by means of the vat. It has been attempted in England to procure the lustre, characteristic of Saxon blues and greens, by obviating the defects which accompany them, and by combining the advantages of the blue vat with those of the sulphuric solution of indigo. Guhliche describes a process for giving silk the English blue and green. These two objects are here united to serve as examples of the different processes which may be practised.

He uses a cold vat for dyeing blue; and he extols it highly in respect of convenience, price, and beauty of colour.

This vat is composed of one part of indigo, three parts of good quicklime, or lime slaked in the air, three parts of English vitriol, and one part and a half of orpiment. The indigo ought to be ground with care, and diffused in water, then put into a wooden vat, in which it is diluted with water to the proper degree, according to the intensity of colour that is wished for; the lime is now added to it; the mixture is well agitated, covered up, and left at rest for some hours. The vitriol, reduced to powder, is thereafter added; the vat is stirred well, and then covered up; after some hours the orpiment in powder is thrown in; it is again left at rest for some hours; the mixture is now stirred, and then allowed to repose till the supernatant liquid appears clear, when the froth that covers its surface is put aside. The silk is now dyed in it hank by hank; but it

must be previously passed through hot water. On coming out of the bath it is washed in running water, and dried. When the bath becomes turbid, it is allowed to settle till it grows clear, an essential precaution for the light shades. When it begins to be exhausted, one-third of the ingredients is added to it, proceeding as at first. In proportion as the vat gets exhausted, the shades become lighter. This vat serves equally well for silk, linen, and cotton. Guhliche thinks that those persons who have not succeeded in dyeing silk with the cold vats, or who complain that only feeble hues are obtained, have been led into an error by employing too small a quantity of orpiment.*

For English blue, a light blue must be first given to the silk. On being taken out of this bath, it is passed through hot water, washed in running water, and put into a bath composed of the sulphuric solution of indigo, to which a little solution of tin has been added, till it has assumed the desired shade, or has exhausted the bath. Before introducing it into this bath, it may be passed through a solution of alum, in which it must not be suffered to remain long. Silk dyed by this process has neither the reddish cast of

* Guhliche uses for wool, a vat composed of one part of indigo, four parts of potash, one part of quicklime, and a part and a half of orpiment. He follows the ordinary process, only he keeps this last bath at a moderate heat. He uses it also, in the same manner, for giving to cloth an English blue and green.

the indigo vat, nor the greenish cast of Saxon blue.

To make English green, which is more beautiful than ordinary green, and more durable than Saxon green, Guhliche gives the silk, first of all, a clear blue in the cold vat: he steeps it in hot water; washes it in running water; passes it through a weak solution of alum; prepares a bath with the sulphuric solution of indigo, a little of the solution of tin, and a tincture of Avignon berry, made with a vegetable acid. He keeps the silk in this bath till it has assumed the wished-for shade; he then washes and dries in the shade. The lighter hues may be dyed in the sequel. The shades may be varied with more or less blue, more or less yellow, by the proportions of the indigo solution, and of the yellow substance. When it is wished to give a gosling-green *(verd d'oie)* to silk, a light blue is communicated to it, either in the hot vat or in the cold; it is passed through hot water, washed in running water, and while moist, it is passed through a bath of annotto.

To give a green colour to linen and cotton yarns, it is proper to begin with scouring them well; then they must be dyed in the blue vat, cleansed in water, and passed through the weld process.

The strength of the blue and the yellow is proportioned to the colour that is wanted. As it is difficult to give uniformity to (*unir*) the cotton velvets in the ordinary blue vat, they are usually dyed yellow with curcuma (turmeric), and the

green is produced with solution of indigo in sulphuric acid. It is of no consequence whether the blue or yellow be first given.

Le Pileur d'Apligny describes a process for dyeing of a water-green, or apple-green, by a single bath, cotton velvet as well as cotton hanks.

Verdigris is to be mixed with vinegar. The mixture is to be kept well corked for 15 days in a stove. Four hours before using it, there is added a solution of a quantity of crude pearl ashes, equal to that of the verdigris; and the mixture is kept warm. The yarn or the velvet is prepared, by soaking in a hot solution of alum, at the rate of an ounce of this salt, and five litres of water to one pound. The stuff is lifted out, the verdigris liquor is added to the bath, and it is immersed again in order to be dyed.

All the shades of olive and drake's-neck green are made by giving to the yarns a blue ground, galling them, and passing them through the bath from the *tonne au noir* (black cask), of greater or less strength, then through the bath of weld with verdigris, and after this through a bath of sulphate of copper. Lastly, the colour is brightened by means of soap.

Chaptal obtains beautiful greens on cotton by the following processes. 1. He passes the cotton dyed sky-blue, through a strong decoction of sumach, leaving it in it till the decoction be well cooled. He dries it, passes it through the mordant of acetate of alumina, dries again, washes, and works the cotton for two hours in a tepid

bath, in which about 12 kilogrammes of quercitron have been infused for 50 kilogrammes of cotton.

2. For 100 kilogrammes of cotton, he mixes 50 kilogrammes of alum, 10 of sulphate of copper, 10 of sulphate of iron, 7½ of acetate of lead, 1½ of soda, and as much chalk. He passes the cotton dyed blue through this, then through lime water, and afterwards through a bath of quercitron.

Chaptal has remarked, that the yellow of weld unites ill with that of sumach, and that the mixture of their colours gives a bad tint to blue; but that on passing the cotton afterwards through a ley marking 12 degrees, the colour becomes uniform, and is pretty fast. The colour of weld unites perfectly to that of tan. He prefers, however, to dye cottons intended for green in a blue vat, mounted with sulphuret of arsenic (orpiment), because it is difficult to obtain a fine green if there be in the vat too large a proportion of sulphate of iron.

When a green ground is wished for upon cloth, acetate of alumina is printed on, and a reserve is applied to the parts that are to remain white, or to those already covered with alumina, which are to take only a yellow colour. The piece is dyed blue, washed with great care to remove all the reserve, and then dyed in weld. It often happens, that the parts of the design which should remain white, take colour in the welding, because the salts of copper and the pipe clay, which constitute the reserve, enter into combination with

the cloth. It might be first dyed yellow, but it then becomes impossible to restore the reserve exactly. When there is but little white in the design, the reserve is applied with the pencil.

If with yellow, green, and blue colours, others produced by madder are to be mixed, these should be finished before giving the blue dye.

When the objects to be dyed green are small, or of an irregular form, like leaves or flowers, the blue is put on with the pencil, after finishing all the colours. The green is often made on common cloths, by applying the blue over the rust yellow, or this over the blue. Thus a sombre green, inclining to the *merd' oie*, is formed, which is seldom evenly. The difficulty with which the two colours combine prevents this method, otherwise economical, from being employed for dyeing cotton in hanks.

Cotton, which has received a blue with prussian blue, may be dyed green, according to the process described in Sect. II. Chap. V. of the Second Part. The piece, while still moist with the blue, is alumed,* and passed through a bath of weld, of greater or less strength, according to the shade. Weld causes a livelier colour than old fustic, which deepens more, but deadens a little the vivacity of the blue. If a green, inclining to olive, be wanted, yellow wood (fustic) is preferable. It is dried in the open air, as for blue.

We have described in the same place, the process by which a beautiful blue may be obtained

* L'art du fabriquant de Velours de Coton.

from the combination of prussiate of iron with the stuff. This process applied to cotton, previously dyed olive by means of alumina and oxide of iron used as mordants, and a yellow colouring substance, affords a more beautiful green than what can be procured by any other method. In this operation, the iron combines with the prussic acid, forming blue, while the alumina constitutes a yellow with the colouring substance. Bancroft was correct in combating the explanation given of this formation of green, in which the co-operation of alumina was not introduced.*

This green, which resists well the action of light and air, is destroyed by alkalies; and the observations made on blue must be applied to it.

The green obtained by giving a yellow colour to a stuff which has been previously dyed blue, and afterwards washed, presents nothing obscure. The colour inclines more or less to yellow, or to blue, according to the tint of blue given, and the strength of the yellow bath. The intensity of the yellow is increased by alkalies, by sulphate of lime, by ammoniacal salts. It is diminished by acids, alum, and solution of tin. The shades vary likewise from the nature of the yellow substance employed.

These different effects will be obtained with the same ingredients in the formation of the Saxon green, according to the process adopted. If the Saxon blue be first dyed, and the yellow

* Annal. de Chim. tom. xiii.

colour be next given separately, the effects will be analogous to those just mentioned. But if solution of indigo be mixed with the yellow ingredients, the results are not the same, because the sulphuric acid acts in this case on the colouring particles, impairing the intensity of the yellow.

It has been formerly remarked, that the sulphuric acid retained by the stuff in the Saxon blue, produced this effect always to a small extent; which makes fustic be preferred to other articles for this species of dyeing.

When a *suite* of shades is to be dyed, in a bath composed of yellow and solution of indigo, the latter incline more and more to yellow, because the molecules of the indigo attach themselves to the stuff, in preference to the yellow, which thereby becomes predominant in the bath.

Although the sulphate of copper, and even the verdigris, sometimes used, principally for dyeing linen and cotton, possess in themselves a blue colour, they give however to the stuff a greenish shade, because the oxide of copper which fixes on it, assumes this colour in several circumstances, and particularly when exposed to the atmosphere. This colour is changed to an olive hue, by means of a yellow substance.

CHAPTER II.

Of the mixture of Red and Blue.

From this mixture are obtained violet, purple, (columbine) dove-colour, pansy, amaranth, lilac, mallow, and a great many other shades, determined by the nature of the substances, whose red colour is combined with a blue colour, of which one becomes more or less predominant over the other, according to the proportions of the ingredients, and the other circumstances of the process.

Stuff dyed scarlet, takes, according to the observations of Hellot, an unequal colour, when blue is to be united with it. It is proper, therefore, to begin with the blue ground, which, even for violet and purple, ought not to be deeper than the shade denominated sky-blue. A *bouillon* is given with alum, mixed with two-fifths of tartar; the stuff is next passed through a bath composed of nearly two-thirds as much cochineal as for scarlet, to which tartar is always added. The purple process is distinguished from the violet one, because, for the first, a lighter blue ground is given, and a somewhat greater proportion of cochineal is employed. These colours are often dyed in the sequel of the *reddening* bath of scarlet, by adding the quantities of cochineal and tartar deemed necessary. The operation is conducted in the same manner as for scarlet.

Lilacs, pigeon-necks, mallows, &c. are passed usually through the *bouillon* that has served for violet, with the addition of alum and tartar. The blue ground is proportioned to the shade wanted, as well as the quantity of cochineal. For some reddish shades, as peach-blossom, a little solution of tin is added. It may be remarked, that although the quantity of cochineal is diminished when a light shade is wished for, yet the quantity of tartar is not, so that its relative proportion to the cochineal is greater, the lighter the colour is to be.

Poerner conceives, that in order to obtain the colours which result from red and blue, there is an advantage in using solution of indigo in sulphuric acid, because a great variety of shades may more easily be procured, and because the process is not so long or expensive. But the colours thereby obtained are less durable than when the blue vat is employed. He says, however, that they have sufficient permanence, if a solution of indigo be used to which some alkali has been added.

The effects may be easily varied, by giving a preparation to the stuff with different proportions of alum and tartar, or with solution of tin; and by dyeing with different proportions of cochineal and solution of indigo.

In silks, two kinds of violets are distinguished; the fine violet and the spurious. The last is made either with archil, or brazil wood.

For fine violet, the cochineal dye is first given, and the vat is then used. The silk is prepared, and receives the cochineal as for crimson,—with this difference, that neither tartar nor solution of tin, which serve to heighten the colour, is put into the bath. More or less cochineal is introduced, according to the intensity of the shade that is wanted. The ordinary dose for a fine violet is an eighth of cochineal to one of silk. When the silk is dyed, it is washed, with two beetlings, in the river; it is next passed through a vat of greater or less strength, according to the depth which the violet is to have; and, lastly, it is washed and dried with the precautions proper for all colours that are dyed in the vat. In order to give more strength and beauty to the violet, it is usually passed through the archil bath; and this practice, frequently abused, is indispensable for the light shades, because the colour would otherwise be too dull.

When silk has been dyed with cochineal, as above directed, a very light shade of blue must be given it for purple. Only the deepest shades are passed through a weak vat. For those which are less so, cold water is had recourse to, into which a little of the blue vat is put, because they would take too much blue in the vat itself, however weak it may be. The light shades of this colour, such as pink, gridelin, and peach-blossom, are made in the same manner, with a diminution of the proportion of cochineal.

The spurious violets are given to silk in various ways. The most beautiful, and those most in use, are prepared with archil. The strength of the archil bath is proportioned to the colour wished for: the silk, to which a beetling in the river has been given on its coming out of the soap, is turned through it round the skein sticks. When the colour is thought to be deep enough, a trial is made on a pattern in the vat, to see if it takes the violet that is wanted. If it is found to be at the proper pitch, a beetling is given to the silk at the river, and it is passed through the vat as for fine violets. Less blue, or less archil, is given, according as the violet is wished to incline to red or to blue.

Beautiful violets may be produced on silk by means of solution of indigo; but they have little permanence, and become reddish, because the colour of indigo fades first.

A violet is made on silk by passing it through water in which verdigris has been dissolved, instead of the aluming; after which a bath of logwood is given. It here takes a blue colour, which is converted into violet, either by adding alum to the bath, or by passing it through a solution more or less charged with alum, which serves to give a red colour to the particles of the logwood. It is needless to observe, that this violet is very fugitive, and of but moderate beauty. One is made possessing more beauty, and to which much intensity can be given, by passing the

alumed silk through a bath of brazil wood, and, after washing it in the river, through a bath of archil.

Madder also is had recourse to for dyeing cloth after giving it a blue ground. By this means are obtained *couleur du roi*, *minime*, and dull amaranth. Nut-galls are usually joined to the madder, and for light shades brazil wood. A browning to a greater or less degree is given to the deep shades with solution of sulphate of iron. These colours are more beautiful when kermes, and particularly cochineal, are mixed with the madder.

By employing solution of indigo with madder, in the same way as with cochineal, brown colours may be formed, according to Poerner, which incline more to red the less solution of indigo is employed. Alum and tartar may serve for the preparation, but alum should not be put into the bath.

Poerner employs brazil wood, and solution of indigo, for obtaining different colours, which incline more or less to blue and red, by a process similar to that pointed out for cochineal and madder. These colours are beautiful; but it is needless to expect durable colours by this method. The ingredients which procure the greatest fixity to them are, sulphate of lime, sulphate of zinc (white vitriol), acetate of copper (crystals of verdigris), which must be added to the bath.

Logwood is, moreover, had recourse to for obtaining sloe, damascene, purple, as well as other

shades. This wood, joined to nut-galls, communicates all these colours with much facility to wool previously dyed blue. When it is wished to brown them, they are let down again with a little sulphate of iron, by which means shades are obtained which are more difficult to hit by more durable ingredients, but they have little permanence. Fast colours, which have been much esteemed, have, however, been obtained from logwood and fernambucca. To Descroizilles, who is engaged in the arts with the intelligence of a skilful chemist, we owe the following details on the process employed, of which incorrect descriptions have been given.

"Giros de Gentilly," wrote he to the author of the former edition, "is the first who gave success in France to the durable dye with violet wood fixed by solution of tin. He made the first trials at Louviers with MM. Petou the nephew, and Frigard, about twelve years ago. From what he suffered to transpire concerning the ingredients of his mordant, I succeeded in a tolerable imitation. I made a solution of tin in sulphuric acid, then added muriate of soda, red acidulous tartrate of potash, and sulphate of copper. My success was sufficiently great to induce Giros to propose a partnership with me in the very lucrative business which he carried on at Louviers, Elbeuf, Abbeville, Sedan, and in the Pays de Liege. Giros then taught me a much more convenient method of effecting this combination. It consists in making a solution of tin in a mixture of sul-

phuric acid, muriate of soda, and water. To this solution the tartrate and the sulphate were added in powder. We made no less than 1500 quarts of this mordant in 24 hours, in a single vessel of lead moderately heated. We continued this very profitable trade at the rate of 30 *sous* per pound for three years, after which it went on declining, till we lost it altogether. The following was the cause of this: Giros having allowed his secret to transpire, we had imitators, who made it at first worse, afterwards better, than we did. In a composition so complex as this, in an operation so obscure as the fixation of colouring matters, it is almost impossible to attain perfection otherwise than by groping our way *(tatonnements)* amid trials which may be indefinitely varied by the respective doses, and especially by the *modus agendi*; and this much more than could at first be imagined by chemists, who have not been so long occupied with this object as myself. I do not blush, therefore, to acknowledge, that I was forced to abandon this trade, whilst I saw, and still see, persons who are in no respect chemists deriving a creditable profit from it. What led me to give it up entirely was the invention of the new process of bleaching goods, to whose improvement I have almost entirely devoted myself.

"After thus giving you the history of the mordant of the *prune de monsieur*, I present you with the following account of its employment and effects:—

"If it be wool in the fleece which is to be dyed, one-third of its weight of mordant is required; if it be a woven stuff, only a fifth is necessary. A bath is prepared at a temperature which the hand can bear; the mordant is well mixed with it; and the wool or stuff is then immersed. It is to be properly agitated, and the same degree of heat is to be kept up for two hours, which may be even increased a little towards the end. It is then lifted out, aired, and very well washed. A new bath of pure water at the same heat is prepared; a sufficient quantity of violet wood is added to it; the stuff is then let down, and agitated; and the heat is urged to the boiling point, at which it is maintained for a quarter of an hour. The stuff is then lifted out, aired, and carefully rinsed. The dye is now completed. If a decoction of one pound of logwood has been used for three pounds of wool, (and proportionately for the stuffs which require a smaller dose), a beautiful violet is obtained, to which a sufficient quantity of brazil wood gives the shade known by the name of *prune de monsieur*.

"The colouring matters susceptible of being fixed with advantage on wool by this mordant are those of violet and red woods, as also the wood of fustet. Yellow wood (fustic) affords likewise tolerable colours. The colours thus given by the violet and red woods may be afterwards affected by soap or urine in the fulling; and this change, always produced by alkaline substances, may be

remedied by a bath very slightly acid, and a little more than lukewarm, called the brightening (*avivage*). Sulphuric acid is preferred. The colour comes out as deep, and often more brilliant than before this alteration. Wools dyed with this mordant are capable of being spun into more beautiful and finer thread than when alum has been used. By omitting the sulphate of copper, we obtain from fustet and fustic, as well as from weld, more beautiful colours. Madder gives in this case a red-orange colour, but not so deep as with an equal dose of alum. The omission of the sulphate of copper renders the wools much harsher; and besides, the mordant so prepared affords only paltry colours with logwood, and particularly with red wood. One of the great defects of this mordant, before it had been improved, was, and occasionally still is, to make the colours unevenly; whenever they are uniform, they are very beautiful, very harmless, and very soft. This process succeeds equally well on silk. By substituting acetate of lead for sulphate of copper, it succeeds tolerably well with cotton and linen yarn previously galled. The employment and carriage of this mordant are inconvenient, on account of the dense deposite, which half fills the vessel under a corrosive liquid, which can be kept only in hard stoneware. I possess, however, a method of obviating these inconveniencies, by omitting entirely the water in the receipt; by which means I have merely a kind of paste, of a much more commodious employment, and two-fifths cheaper

in the carriage. Now that the muriate of soda is low priced, it may happen that I shall recommence furnishing our dyers with this mordant, which is better, in my opinion, than what they are at present getting, and especially much cheaper. But before doing so, I must devote myself for some time, still, to the composition and employment of your lixivium."

For fixing on silk the colour of brazil and logwood, Fabroni has given a process which we shall copy from Hermstadt. It has a good deal of resemblance to that of Descroizilles. It consists in employing as a mordant, a mixture of muriate of tin, sulphate of copper and tartar. Infusion of nut-galls or birch-wood bark (*écorce d'aulne*), is added to the bath. The proportions of these substances are varied according to the shade that is wanted. For light shades, a little muriatic acid is added.

When the sulphuric solution of indigo is employed, the sulphuric acid acts differently according to the red substance that is used. It changes very little the colour of cochineal, which had, indeed, a tendency to take a crimson colour by the preparation with alum; but it must give a dun colour to madder, on which the acids readily produce this effect; and it is improbable that this substance could be successfully employed in this process. It would be better to have recourse to it for dyeing stuff to which a blue ground had been previously given. Brazil wood and logwood must also be ill qualified to afford beautiful colours

with the sulphuric solution of indigo, because the acids make them turn yellow, although in a less decided manner; but they retain, as we have already remarked, their red colour, when their colouring particles are precipitated by oxide of tin.

If we may venture an opinion, without having made direct experiments on a complicated process, such as that communicated by Descroizilles, and which is still employed advantageously in some manufactories with modifications which we do not know, we would suggest the following explanation.

The muriate of soda is decomposed by the sulphuric acid, and the muriatic acid set at liberty dissolves the tin.

A portion of the tin is precipitated by the tartaric acid, whence the deposite is occasioned. But a portion which remains in solution serves to modify the effect, as we have seen with regard to cochineal. The oxide of copper present in this preparation, forms blue with the colouring particles of the indigo; the oxide of tin with the same wood gives violet, and red with the colouring matter of brazil wood. Descroizilles observed, that a preparation capable of accomplishing this object could easily be obtained, by trying different mixtures, and different proportions, with the muriate of tin: this is what Fabroni has done.

This direct mixture of the blue and red colours gives to cotton yarn and cloth only a sombre hue without lustre, approaching to black, provided

these colours be somewhat deep. But if, after giving a light blue to cotton stuff, we dye it of a rose colour with carthamus, a brilliant deep blue is produced, which fades pretty quickly, from the little permanence of the colour of carthamus.

Chaptal has, however, obtained a tolerably agreeable violet, by dyeing red cottons blue, in the preparation of which he diminished the quantities of oils and nut-galls, and, on the other hand, increased that of alum, as well as the brightening process. He attempted, by a great many experiments, to give cotton a violet colour, which would yield neither in durability nor in lustre to the red made in his dyehouses; and after having been led by his researches to a great variety of processes, which afforded with more or less facility the colour which he wished, he preferred the following, as being the simplest and most certain in the execution.

The mordant for 100 kilogrammes of cotton, is prepared with 25 kilogrammes of sulphate of iron, and 6 kilogrammes of acetate of lead. The clear liquid is to be separated from the deposite that is formed; and the cotton is passed through it with the greatest care, after receiving three oils, as for the Adrianople red, as hot as possible. On taking it out of the bath, it is wrung and well worked: whenever it has assumed, on cooling, the buff shade, it is well washed, wrung out, and dried with accurate stretching.

Its own weight of madder is employed for dyeing; as soon as the bath becomes tepid, the cot-

ton is plunged in, and turned about, with gradual increase of the heat, but without boiling. When the cotton has become bluish-black, it is taken out, and washed. It is thereafter brightened in soap, during 15 or 20 minutes.

For deep violet, he takes cotton which has received only two oils; he passes it through the same mordant with the same care. He adds a pailful of blood to the madder bath, and takes out the cotton when it is about to boil, washes it, and madders a second time with double its weight of madder, and a pailful of blood. He lets the bath boil for a quarter of an hour; and after washing the cotton, he brightens it with 40 kilogrammes of soap, causing the brightening process to boil for a quarter of an hour, and sometimes more than an hour, as he perceives the colour to be impoverished, or to take lustre.

By adding 5 kilogrammes of alum to the preceding mordant, the violet is more brilliant. He used with advantage the solution of iron in pyrolignous acid.

For procuring uniform colours which penetrate thoroughly, he recommends us to employ the mordant very limpid, and as hot as possible; to wash it on taking it out of the mordant; to dry quickly and equally; but not to let the madder bath boil, when it is wished to preserve the lustre of the dye. Lastly, he observes, that soda makes the colour turn red, and that soap gives predominance to the blue; hence, by employing different proportions of these substances, the shades of the

cotton may be varied in the brightening, and blackish cottons may, for instance, be restored to violet by using leys only, whilst if they incline to red, soap alone ought to be used.

To produce violets on printed calicoes, the acetate of iron diluted with water is impressed, and they are maddered. This colour is less easily degraded in the dyeing bath than the reds. It may also be kept boiling for a longer time, so as to raise the deep shades. The bath becomes very foul; the colour comes out of it very dull, and assumes lustre only by exposure on the grass, and ebullition with bran water; it is even rare for the white to become beautiful again. But these inconveniencies are obviated by dunging with a strong heat, which acts less upon this mordant than upon that employed for the reds.

For lilac, a mordant is printed on, composed of very dilute acetate of iron, mixed with a small quantity of acetate of alumina.

Cotton in hanks dyed by the same processes, with difficulty takes an agreeable shade; and the colour never has the permanence of that produced by the processes of Chaptal. The most ordinary method of dyeing linen yarn and cotton violet, consists in giving first a blue ground in the vat, proportioned to the shade wanted, and then to dry it. It is next galled at the rate of 3 parts of nut-galls for 16 parts of the matter; it is left for 12 or 15 hours in the bath of galls; after which it is wrung out, and dried. The linen yarn and cotton are thereafter passed through

a decoction of logwood, and when it is well soaked, it is lifted out, and there are added to this bath 1-60th of alum, and 1-128th of verdigris, both in solution. The hanks passed over the sticks are re-immersed, and they are turned round them for a full quarter of an hour. They are now taken out to let them be aired; they are then re-plunged completely into the bath for a quarter of an hour; after which they are lifted out and wrung. Lastly, the vat which has served for this dye is emptied; there is poured into it one-half of the decoction of logwood, which was reserved; as much alum is added as in the first operation; and the yarn is once more passed through, till it be of the suitable shade. The decoction of logwood should be more or less rich, according to the depth of shade wanted. This violet resists the air tolerably well, but it cannot be compared in durability to the dyes above described, or even to the following:—

The cotton or linen yarn is scoured as usual; a mordant is prepared, composed of four litres of the *tonne au noir* (black cask), and eight litres of water for each kilogramme. This is boiled, and the scum which rises is removed. When no more froth appears, the liquor is poured into a vat, and whenever it is merely tepid, 122 grammes of sulphate of copper, and 30 grammes of saltpetre, are dissolved in it. After this, the hanks are allowed to soak in it during ten or twelve hours, when they are wrung out and dried. When it is wished to madder them, they are washed with

care, and passed through a madder bath. If the violet is to be deep, 61 grammes of verdigris are added to the mordant. The colour may be still further deepened, by galling the yarn more or less before passing it through the mordant, and by leaving out the saltpetre. If the dose of the latter substance be increased, and that of the sulphate of copper be diminished, the violet inclines more towards the lilac. The mordants may be still modified in different manners, so as to produce a great many shades.

CHAPTER III.

Of the mixture of Red and Yellow.

In treating of cochineal, we thought it improper to separate the operations which usually succeed one another in the dye-houses, and therefore the principal shades obtainable by the mixture of the red of cochineal with yellow have been already described. These shades may receive an infinity of modifications from the different proportions of the ingredients; from the yellow substances made choice of, from the preparations given to the cloth, and from the mordants added to the dye-baths. Thus Poerner describes a great many varieties which he obtained, by employing weld, saw-wort, dyer's broom, and some other yellow substances; as also by introducing into the preparation of the

cloth, or into the bath, tartar, alum, sulphate of zinc, or sulphate of copper.

Different colours may in like manner be procured from the madder, which is associated with yellow substances. It is thus that the *mordorés* and the cinnamons are dyed; colours commonly formed in two baths. The maddering is first given, preceded by a *bouillon* of alum and tartar as for ordinary maddering; and then a bath of weld is employed.

For cinnamon a weaker maddering is given, and commonly a bath is used which had served for the *mordoré*. The proportions are varied according as the red or the yellow is wished to predominate. Sometimes nut-galls are added, and sometimes the colour is deepened by a browning.

Occasionally the sole object is to give a reddish tone to the yellow; the stuff just dyed yellow may, in this case, be passed through a bath of madder, more or less charged according to the intention.

Brazil wood is likewise employed along with the yellow substances, and sometimes it is associated with cochineal and madder.

When instead of weld or other yellow substances, root of walnut, walnut peels, or sumach, are used, tobacco, snuff, chesnut, musk colours, &c. are produced.

The marrones, the cinnamons, and all the intermediate shades, are formed upon silk by means of logwood, brazil wood, and fustet.

The silk is boiled as usual, then alumed, and a bath is prepared by mixing the decoctions of the above three woods, which have been separately made. The proportion of each is varied according to the desired shade; that of fustet ought however to predominate. The bath should be of a moderate temperature. The silk is turned round the skein sticks, and when its colour is uniform, it is wrung out, and passed through a second bath of the three ingredients, so proportioned to the effect of the first bath as to obtain the shade wanted.

The mixture of red and yellow requires no peculiar observations, in addition to those which have been detailed in the two preceding chapters.

For some colours, blue is blended with red and yellow; thus olives are made. A blue ground is given, then the yellow bath is used, and lastly, a slight maddering is employed. The shade resulting from this operation, depends on the proportion of the three colours of which it is composed; for the deep shades, a browning is given with a stronger or weaker solution of sulphate of iron.

The blue vat is not used for producing the olives on silk; but after the aluming, the silk is passed through a very strong bath of weld: some logwood is then added to this bath, and whenever the silk is turned through it, a little alkaline solution is poured in, which turns it green, and makes the cloth take an olive hue. The silk is passed again through this bath, till it has taken the

proper shade. For the colour termed *russet olive*, or *rotten olive*, fustet and logwood, without alkali, are added to the bath after the welding. If a more reddish colour be wished for, only logwood is added. A kind of reddish olive is also made by dyeing the silk in a bath of fustet, to which more or less sulphate of iron and logwood are added.

According to Le Pileur d'Apligny, a fine olive is formed on linen yarn and cotton, by boiling, in a sufficient quantity of water, four parts of weld with one of potash; brazil wood, soaked the evening before, is boiled apart with a little verdigris: the two solutions are mixed in different proportions, according to the shades wanted, and the thread or cotton is passed through the mixture.

The colours which result from the mixture of yellow with red, as *coquelicot*, brick, capuchin, &c. are obtained in calico-printing by means of weld and madder. Acetate of alumina is printed on as the mordant; and a slight maddering, with a welding finish, is given.

To vary the shades, it is sufficient to increase or diminish the duration of one of the two dyeing operations, or the proportion of the materials employed. These processes are applicable to the dyeing of cotton in hanks, (cotton yarns).

CHAPTER IV.

Of the Colours resulting from the mixture of Black with other Colours, and of Brownings.

THE processes by which the degradations of black are obtained that form the different shades of grey, have been already described. It has been shewn, that dissimilar (*étrangères*) shades might be blended with them, so as to cause them to incline towards certain colours; but the black is often employed for certain colours which are to remain predominant, and which should be merely browned. At the same time, they become more durable. In the course of this work, it has been frequently stated, that a browning was imparted to certain colours; but this chapter is destined to treat peculiarly of this operation, and of the resources which it presents to the art, sometimes for the purpose of imitating colours that can be obtained by other means, and sometimes for producing new colours.

To give a browning, the stuff just dyed is passed through a solution of sulphate of iron with which an astringent is mixed, and which consequently forms a *black bath*. More frequently there is added to a water bath, a small quantity of solution of iron; and just so much is introduced, as to make the dyed stuff attain the wished-for shade. More rarely, some sulphate of

iron is added to the dyeing bath. But the desired effect is obtained with more precision, by passing the coloured stuff through solution of sulphate of iron. Poerner often macerates the stuff in a solution of sulphate of iron, to which other ingredients are sometimes added; and on its quitting this mordant, he passes it through a dyeing bath.

The first method is employed for marrones, coffees, damascenes, and other brown shades of the common dye; greater or less depth of colour is given, according to the colour wished to be obtained by the browning; a bath is next made with nut-galls, sumach, and alder bark, to which sulphate of iron is added. The stuffs which are to be lightest coloured are first passed through; and when they are finished, those that are to be browned are dipped, adding at each operation a quantity of sulphate of iron proportioned to the purpose in view.

The other brownings offer nothing peculiar in the operation. We shall select some examples of the effects that are obtained, and point out some particular processes.

It has been stated in the *first section* of this *Second Part*, that for several kinds of grey a slight blue ground is given. Poerner makes bluish-greys by employing sulphuric solution of indigo, which he adds to a decoction of gall-nuts with sulphate of iron; and he varies the shades by the different proportions of these three ingredients. He procures other shades, by adding

sulphate of iron to a bath composed of cochineal, fustic, and gall-nuts.

For *couleur du roi*, a sky-blue ground is given with pastel, the dyeing is performed with weld and a sixth of gall-nuts, and a browning is imparted with the solution of sulphate of iron.

The marrone, and the colours approaching it, are made with sandal wood, gall-nuts, and a browning; sometimes fernambucca (brazil wood) is added. To these colours a cast of purple and crimson is given, by dyeing them in the remains of a cochineal bath, with the addition of a little madder and cochineal to the bath. The colour is rendered lighter by means of a little tartar.

For the hazel colours, gall-nuts, fustic, and logwood, are blended, to which more or less madder, and a little alum, are added.

Logwood and brazil wood, being employed in equal parts, or in other proportions, afford different brown colours of tolerable durability, when more or less solution of iron is mixed with their decoction, and when the wool previously alumed and galled is dyed in it. These colours cannot be compared, however, with the preceding in respect to permanence.

To the above colours, different shades of mordorés and capucine may be given, by passing them through a bath of annotto, on their coming out of the dye.

A great variety of shades are obtained by the mixture of brazil wood, logwood, archil, gall-nuts, and by a browning with sulphate of iron; but

these shades are all more or less fugitive, although they possess an alluring lustre.

When a stuff, which has received a colour, is passed through a black bath more or less dilute, the effect obtained is simple; a black shade, more or less deep, is blended with the first colour.

This is not the case when the coloured stuff is passed through a solution of sulphate of iron: here the colouring particles that are fixed on the stuff act on the sulphate of iron, seize a portion of its oxide, combining it with them and with the stuff. The colour that results from this combination is more or less deep, not according to the colour peculiar to the colouring particles, but principally according to the action which they exercise on the metallic oxide, agreeably to the principles laid down in the *First Part.* Thus the brazil wood and logwood, which enter into the composition of a colour, will produce a much more marked effect in the browning, than madder and cochineal; nut-galls and sumach will occasion a still more considerable one, although they had affected the primitive colour only by a dun-coloured shade.

If a black bath be prepared, or a black dye be formed, either in the mordant, or in the dyeing bath, the ingredients which are mixed with the colouring substances modify the result of the operation, by the action which they exercise on the black molecules: thus alum, solution of tin, solution of indigo, will impair the effect that

the black molecules would have produced. All the acids act in the same way, excepting acetic acid, and some analogous vegetable acids, which do not possess the property of dissolving the black molecules. It appears that nitre can dissolve them, since it renders the colours for which it is employed lighter.

As the best colours that can be given to linen and cotton are derived from madder, attention must be paid to the methods described, in treating of madder, for rendering this dye more durable, and its colour may be deepened by different black baths.

For some hazels and snuff colours, a browning is given, after the welding and the madder bath, with soot, to which gall-nuts and fustic are joined. Soot is sometimes mixed with this bath, and a browning is moreover given with solution of sulphate of iron.

Walnut peels are occasionally substituted for solutions of iron, in browning colours. They have a great advantage for the wools intended for *(tapisseries)* tapestry. The colour does not become yellow by long exposure to the air, as happens to the brownings from iron; but it keeps long without alteration. It has, indeed, a dull tone, suitable for shadows, and for representing the flesh in old figures, which would produce merely gloomy colours, without lustre, on cloths. The goodness of this colour, however, and its cheapness, ought to extend its use for the sombre

colours which are sometimes in fashion, at least on common stuffs.

A great number of shades are made at the Gobelins, by means of this browning. To procure an assortment of them, a *bouillon* is first given to the woollen yarns with tartar and alum, of different degrees of strength, according to the shades required; they are then successively dyed red, yellow, or some other colour, recurring to the bath from which most effect is wished to be obtained. When the colour is found to be of the desired shade, it is passed, for a shorter or longer time, through the bath of walnut peels, of a strength adjusted to its purpose. This browning is likewise had recourse to for silk; but the bath must be hardly tepid, in order to avoid the inequalities to which it is so liable.

For the different shades of marrone, the cotton is galled, passed with the ordinary manipulation through water, into which a greater or less quantity of the black cask (*tonne au noir*) has been poured. It is next worked in a bath in which verdigris has been dissolved; and a welding is given it. It is dyed in a bath of fustic, to which solution of soda and alum are sometimes added. When the cotton which has received these preparations has been well washed, a good maddering is given it. It is then passed through a weak solution of sulphate of copper, and lastly through soap water.

The cinnamon and *mordoré* colours are given to linen and cotton, by commencing the dyeing

with verdigris and weld; they are next passed through a solution of sulphate of iron, which is called the security bath (*bain d'assurance*), and they are wrung out and dried. When dry, they are galled in the proportion of 122 grammes of gall-nuts per kilogramme; they are once more dried, alumed as for red, and maddered. When they are dyed and washed, they are passed through very hot soap water, in which they are turned round the sticks till they are sufficiently brightened. Decoction of fustic is sometimes added to the aluming.

By taking cotton which had received the requisite preparations for the Adrianople red, and had been galled, then passing it through nitrate of iron, galling it anew and aluming, Chaptal obtained a pretty *nacarat*. He prepares the nitrate of iron with the aquafortis of commerce, diluted with half its weight of water, into which he plunges fragments of iron, which he removes whenever he perceives the solution slackening. The liquor is now of a yellowish-red, strongly acid, and marks from 40° to 50° on the areometer (of Baumé).

If after galling the cotton that has passed through the oils, it be alumed in a bath, to which one-eighth of this solution of iron, for one of cotton, is added, the cotton comes out black, and takes a violet sloe colour by the maddering and brightening.

Chaptal obtains a succession of shades by passing the cotton, which has received two or three

oils, through a mordant composed of alum, sulphate of iron, and acetate of lead, and by varying the proportion of the salts which enter into its composition. Thus, with three parts of alum, two of acetate of lead, and one of sulphate of iron, maddering twice, and brightening with 25 kilogrammes of soap, he produced a sloe colour, inclining towards red. He had, on the other hand, a sloe verging towards violet, by galling with nut-galls and sumach, passing through a mordant prepared with 122 grammes of sulphate of iron, 122 grammes of alum, 61 grammes of acetate of lead, 30 grammes of muriate of ammonia, and as much soda, dissolved in two kilogrammes of water, maddering, passing through a boiling ley which marked 2°, and brightening with soap.

He took advantage of the difficulty with which alumed and dried cotton is impregnated with water, for dyeing it at once of two colours, which produce the effect of small *chinures* (veins?), very close together, and very irregular. With this view, after having galled, alumed, and dried the cotton which had been treated with the oils, he washed it and dried it anew; then he passed it slightly through one of the above mordants. The down alone (on the surface) is coloured black, and the thread remains grey: after the maddering and brightening, the latter is red, and the down has assumed a violet colour. Cottons dyed in this manner have a very agreeable appearance. Employed in weaving, they produce cloths whose

reflections vary, and take different tints, according to their relative position, and that of the dye.

In the manufacture of printed calicoes, colours are obtained from madder, which result from the mixture of red and black. For mordants, mixtures, in different proportions, of acetate of iron and acetate of alumina are employed.

By printing on a mordant, composed of equal parts of oxidized acetate of iron *(black bouillon)* and acetate of alumina, both concentrated, a deep *mordoré* is obtained with madder. One part of acetate of iron, and two of acetate of alumina, afford a less sombre *mordoré*, inclining towards puce-coloured. On augmenting the quantity of acetate of alumina, the shade approaches more and more to red; and on introducing, at last, only 1-12th of acetate of iron, an amaranth colour is obtained. If, on the contrary, the proportion of acetate of iron be increased, browns are produced.

This colour is that which requires most madder. It may be boiled longer than for the reds, but not so long as for the violets, because, as the portion of the colouring matter which is combined with the alumina does not stand a prolonged ebullition so well as that which has the oxide of iron for a mordant, the shade is degraded, and there is obtained only a poor and unequal colour, instead of a substantial and well raised one. Great care should also be taken to put into the bath a sufficient quantity of madder, so as to saturate all the mordant; otherwise a uniform

colour can never be obtained, for the bath becomes exhausted, and some parts of the cloth would be saturated before other parts had been able to assume the proper shade. For conducting the operation properly, and for completely saturating the mordant, the maddering should be given at two times. The bath is scarcely suffered to boil the first time, and from the hue that the cloth has taken, the quantity of madder to be employed at the second maddering may be determined. When the cloth is to have, besides the *mordoré*, fainter colours, they should not be printed on till after the first maddering, because the heat of the bath in the double maddering would degrade them.

The *mordorés* have a more agreeable hue, when, previous to maddering, they have been dyed with nearly half the quantity of weld or quercitron which would have been used had they been dyed with these substances alone. The mordants for *mordoré* and puce afford, with both these substances, the shades of olive, bronze, terre d'Egypte, &c. In this case, it is sufficient for restoring the white, to pass through bran on their quitting the boiler, and to expose them for about eight days on the grass, lifting them once in this interval in order to wash and beetle them. The colour has more lustre when, before drying the cloth, we pass it through water acidulated so slightly with sulphuric acid, as to be hardly perceptible to the taste.

These processes may be employed for dyeing cotton in hanks. The greatest precautions should then be taken to impregnate and dry the cotton very equably; for many difficulties are encountered in preventing some parts from being unequally charged with the one mordant or the other.

NOTES,

ILLUSTRATIVE & SUPPLEMENTARY,

BY

THE TRANSLATOR.

NOTES

TO

THE FIRST VOLUME.

Note A. p. 53.

The green of plants, whose colour M. Berthollet regards as simple, is a substance which has been lately examined under the name of *Chlorophile*, by MM. Pelletier and Caventou. They obtained it by pressing, and then washing in water, the substance of many leaves, and afterwards treating it with alcohol. A matter was dissolved, which, when separated by evaporation, and purified by washing in hot water, appeared as a deep green resinous substance. It dissolves entirely in alcohol, ether, oils, or alkalis; it is not altered by exposure to air; it is softened by heat, but does not melt; it burns with flame, and leaves a bulky coal. Hot water slightly dissolves it. Acetic acid is the only acid that dissolves it in great quantity. If an earthy or metallic salt be mixed with the alcoholic solution, and then alkali or alkaline subcarbonate be added, the oxide or earth is thrown down in combination with much of the green substance, forming a lake. These lakes appear moderately permanent when exposed to the air. Chlorophile is supposed to be a peculiar proximate principle.

Note B. p. 73.

Messrs Thenard and Roard published, in the Annales de Chimie, vol. lix., a very interesting memoir on mordants, in which the effects of alum, acetate of alumina, tartar, and the solutions of tin upon vegetable and animal substances, are examined and analyzed. This memoir is translated into the 39th vol. of Tilloch's Magazine.

Prior to their experiments, it had been generally supposed, that in the process of aluming, the alum was decomposed, and that the alumina combined with the stuff, thereby causing it more readily to take the colour when plunged into the dyeing bath; but Messrs Thenard and Roard came to a different conclusion.

Analysis of the Aluming of Silk.

Ninety-five grammes of silk, well cleaned, and perfectly purified, were infused in a glass vessel during six days, at the common temperature of the atmosphere, with four quarts of distilled water, containing 100 grammes of pure alum, which had been previously dissolved in it. After standing this time, the silk was taken out of the liquid, drained completely over the bath, and washed several times with distilled water, to separate that part of the mordant which had not combined with it. The alum bath and the washings were then evaporated with the greatest care, and they afforded very transparent crystals of alum. These first products indicated pretty clearly the nature of the combination which had been formed with the silk during the steeping, and that the alum had not been decomposed. The alumed silk was then boiled in a matrass with six quarts of distilled water, the boiling liquor was poured off from it,

and in this manner it was treated twelve times. The 72 quarts, proceeding from these operations, being evaporated, we obtained well formed crystals of alum, the quantity of which, added to that obtained from the bath, amounted to within two decigrammes of the ninety-five grammes originally employed, forming a loss of $\frac{1}{420}$ part only. If after each of the twelve washings we attempt to dye the silk, the colour is less deep, in proportion to the number of washings, so that after the twelfth, the silk is not at all coloured. If the silk, after having thus been washed, is again impregnated with alum, it reacquires the same property of retaining the colour which it had before the washing commenced. Hence results a very natural explanation of the reason why alumed silks take a deeper colour when the dyeing is commenced at a low temperature, than when they are plunged into boiling baths; it is because, in the one case, the action of the boiling water upon the mordant is so speedy, that there is not time for the colouring matter to fix upon it, and render the combination insoluble, whilst in the other case, no such effect takes place.

Analysis of the Impregnation of Wool with Alum.

After having thus ascertained the phenomena which take place in the aluming of silk, it was necessary to continue the trials upon wool, and to employ for these experiments only perfectly pure materials, completely deprived of the carbonate of lime, which is generally contained in considerable quantity. To separate the whole of this, we boiled the wool several successive times, in a matrass with weak muriatic acid; but in order to take up the last portions of this acid, we were obliged to make use of such large quantities of distilled water, that we were on the point of abandoning such tedious experiments, requiring so much time and patience, as well as the greatest care. The separation of all the muriatic acid

from the first two hectogrammes of wool which we purified, required 200 quarts of distilled water, at 100° of heat (212° F.), divided into twenty successive operations, each occupying from seven to eight hours. When calcined and properly tried, it afforded neither lime nor muriatic acid.

One hundred grammes of this wool were alumed with the same care which had been taken with the silk. It was afterwards washed twenty times, employing six quarts of distilled water, heated to 100°, for each washing. Immediately after the aluming, this wool took a very deep colour, whilst after the last washing, it would not take any more colour in the dyeing bath, than some of the same wool which had never been alumed. These experiments convinced us, that the substance which had been fixed in the wool by aluming, and had caused it to receive so deep a colour in the first dyeing, had now been carried off by the water. The alum bath, when evaporated, afforded us, in the state of crystals, two-thirds of the quantity of alum we had originally employed; very nearly the whole of the remaining third part was obtained from the residue of the bath, in an uncrystallized state, and from the washings of the wool. This experiment was repeated several times, and always with the same result; but as this did not appear to us so decisive as the experiment upon silk, on account of the difficulty of separating the animal matter from the last portions of the alum bath, we alumed some wool in the cold as we had done with the silk, and we obtained from the bath and the washings the alum employed in the operation, with a loss only of $\frac{1}{400}$ part: we were therefore assured, that in the aluming of all animal substances, the alum combines entirely with them, without undergoing any decomposition, and that it forms with them combinations more or less soluble, which have a great affinity for the colouring matters.

Analysis of the Impregnation of Cotton and (Linen) Thread with Alum.

Having freed some cotton, by the methods already mentioned, from all foreign matters, we macerated it for two days in a lukewarm solution of a given quantity of alum. After this operation, the stuff took the dye remarkably well; but being treated with boiling distilled water, it lost the property of taking the colour in the dye bath. The alum bath and washings, when evaporated, afforded us all the alum we had employed. We separated this alum from the vegetable matter which it had dissolved in its different crystallizations. To do this, did not require such a number of washings as were employed for the wool or the silk, because the combination of alum with vegetable substances is so weak, that soaking the alumed cotton in boiling water for a few minutes, is sufficient to carry off the greatest part of the mordant. Cotton, therefore, ought to be dyed at a low temperature, since it is only after the colouring matter has rendered the combination insoluble, that it can support a great heat without being attacked. Thread treated in the same manner as cotton, afforded us the same results.

Analysis of the Impregnation of common Wool.

The analyses we have already related most decidedly demonstrate, that in the aluming of all animal and vegetable substances, the alum combines with them without undergoing any decomposition; but we thought it was necessary to repeat the same experiments upon these substances, in the state in which they are commonly met with in commerce, as we had done in their purified state. Wool, when impregnated with alum alone, always renders the bath turbid, which, upon cooling, throws down

an abundant white precipitate, as has been observed by several chemists. Several analyses of this sediment, after being well washed, have constantly afforded us some sulphate of lime, saturated sulphate of alumina, and sometimes a little alumina. The bath contained a remarkable quantity of alum, of acidulated sulphate of potash, combined with a small proportion of animal matter. Upon the wool we found alum, and a very minute proportion of the precipitate. These experiments upon the sediment formed in the alum bath, do not differ from those made by M. Berthollet; but this learned chemist not having examined the mother waters, nor the alumed wool, has not given, as he himself says, a clear and precise explanation of the effects produced by alum and tartar in the operation of dyeing. These precipitates, obtained by treating common wool with alum, never take place with purified wool; and as these only differ from each other by the former containing some carbonate of lime, it was natural in this case to attribute to this substance the decomposition of a part of the alum.

We satisfied ourselves of this, by mixing in glass vessels solutions of alum in boiling water, with different proportions of pure carbonate of lime. We always found the alum was decomposed by the carbonate of lime, and that if a sufficient quantity was added, there remained no part of the aluminous salt in solution. The mother waters contained very acid sulphate of potash, and the sediment was formed of sulphate of lime and acidulate sulphate of alumina and potash; whence it follows, that the property possessed by common wool, of forming a precipitate in the alum bath, and rendering the fluid very acid, is in reality owing to the carbonate of lime it contains. The same result was obtained by aluming common wool five or six successive times in the same bath. But in order to arrive at a general solution of this question, it was necessary to ascertain the nature of the precipitates formed

in the solution of alum, by different alkaline and earthy substances. We took, therefore, alums with base of potash, and with base of ammonia, which we treated with ammonia and carbonate of potash, so as to leave in the solution but a slight excess of alum. The mother waters evaporated, contained very acid sulphates of ammonia, of potash and ammonia, and of potash, according to the nature of the alum and of the precipitate employed. The sediment, which was acid sulphate of alumina and potash, or ammonia, treated with sulphuric acid, afforded alum and acidulated sulphate of alumina; boiled afterwards a great number of times with distilled water, it was converted into alum, sulphate of potash, and pure alumina. There was always a greater quantity of acidulated sulphate of potash than of alum, even in the last washings.

Solutions of alum, treated at a boiling heat with pure alumina, were converted into a very acid sulphate of potash, and into acidulated sulphate of alumina and potash. These results do not at all correspond with those obtained by M. Vauquelin in his experiments upon the alums of commerce, for we have never been able to obtain the saturated sulphate of alumina and potash, spoken of by that celebrated chemist.

Thus all the alkaline and earthy substances mixed in suitable proportions with solutions of alum, converted that salt into acidulated sulphate of potash or ammonia, and into insoluble acid sulphate of alumina and potash, or ammonia, for which reason we have named it the acidulated sulphate, instead of the saturated sulphate, the name it has borne until now. It is evident, that if too great a quantity of carbonate of lime be employed, and the same holds good with the carbonates of barytes and strontian, we shall only obtain alumina and the sulphates of potash, lime, barytes, or strontian. There remains no doubt, therefore, of the nature of the changes pro-

duced in the alum baths by the common wools, and of the prejudicial effects of alkalies in the baths intended for cottons; for the addition of these substances diminishes the quantity of alum, and even increases the acidity of the bath.

On the Impregnation of Vegetable and Animal Matters with Acetate of Alumina.

Wool, silk, cotton, and thread, in the different states in which these substances are employed for dyeing, were treated with acetate of alumina, which combined entirely with them. But as in exposing them to the air, or to a temperature a little elevated, the mordant always looses a small quantity of acid, it follows that the combination formed upon the stuff, is an acetate with excess of base: thus, by treating it with boiling water, it is converted into acidulated acetate of alumina, which is dissolved, and into alumina which cannot be carried off by the water.

Of the action of Acidulated Tartrate of Potash on Wool.

Purified wool was treated, as in the former experiments, with very pure cream of tartar, free from tartrate of lime, and formed directly by the tartaric acid and potash. This wool was washed a great number of times, until the last washing did not contain any of the principles which had been combined with it. The bath afforded, by evaporation, three-fourths of the cream of tartar employed, or rather neutral tartrate of potash. The washings were very acid, and we obtained from them a small quantity of cream of tartar, and a very acid composition, formed of tartaric acid and wool. These facts may be thought sufficiently to explain the phenomena which take place in impregnating wool with alum and

tartar, since we already know, from the experiments of M. Berthollet, that these two salts are not decomposed; and as we have shewn that the wool combines completely with the alum, and that it acts upon the cream of tartar by separating the tartaric acid, with which it unites in the most intimate manner. But in order to have these facts rigorously demonstrated, we repeated this experiment, although a very tedious one, in the method already pointed out in the preceding chapters.

Of the action of Alum and Tartar upon Wool.

Before treating the wool with alum and cream of tartar, we made some trials of the reciprocal action of these two salts. We ascertained that water, at the temperature of 12° or 14° (65 F°.), holds in solution only $\frac{1}{150}$ part of its weight of cream of tartar; that boiling water dissolves $\frac{1}{50}$ of its weight, and that a mixture of equal parts of alum and cream of tartar dissolves in $\frac{2}{3}$ the quantity of water required to dissolve the salts separately at the same temperature. These results do not differ from those already obtained by M. Berthollet, who has shewn that alum has the property of increasing the solubility of cream of tartar.

If wool is alumed in the ordinary proportions, which are $\frac{1}{4}$ of the weight of the stuff of alum, and $\frac{1}{10}$ of cream of tartar, all the substances being perfectly pure, we obtain from the bath, when evaporated, alum, cream of tartar, and a residue difficultly crystallizable, composed of tartrate of potash and an animal matter: the washings of the wool will give alum, a small quantity, scarcely appreciable, of cream of tartar, and a very acid combination, formed of a large quantity of tartaric acid, alum, and animal matter.

These experiments remove all uncertainty concerning many practical facts, which at present are only noticed

by the dyer in a vague way, and point out to him the precise method of applying the mordants, according to the nature of the colour he wishes to obtain. Indeed, since by making use of alum and tartar, the wool is impregnated with alum and a large quantity of tartaric acid, these two salts should never be employed together, except where the colour is susceptible of being heightened and rendered brighter by acids, as is the case with cochineal, madder, and kermes. On the contrary, alum should never be employed for wools intended to be dyed with woad or brasil wood, the colour of which is easily altered or destroyed by acids. Among all the vegetable and animal substances, we have made choice of wool only for trial with alum, and alum and tartar, because it is only with this substance these mordants are made use of in dyeing.

On the action of Acids, and of some Salts employed as Mordants upon Wool.

Although all researches hitherto made have been ineffectual to find a substitute for alum, we have nevertheless made trial of a great number of substances with wool; less, however, for the purpose of discovering the best mordants, than for determining the action of several substances very soluble, and at the same time endowed with great powers. We boiled wool for two hours in water, in which were put small quantities of sulphuric, nitric, muriatic, and tartaric acids. In each instance, the wool, especially when combined with sulphuric acid, struck with cochineal and madder deeper colours than when impregnated with alum and tartar. No doubt, therefore, can be entertained of their superiority in similar cases; but of all the mordants we tried, there is not one which gives such bright colours as what are obtained by means of the acid tartrate of alumina, (notwithstanding

the opinion of M. Hausmann to the contrary). This salt would, in a great number of cases, be preferable to tartar and alum, if its price was not so much higher than theirs. Whilst we were occupied in inquiring with the greatest care into every thing relative to the nature and mode of combination of mordants with various stuffs, we did not forget to examine the several methods which have been adopted in the work-shops for a long time past, in order to ascertain if the proportions of alum and tartar, the most generally employed, were those the most suitable for the purpose; if the time employed for the alum bath was sufficient to impregnate the wool sufficiently; and if the exposure to the cool air afterwards, for several days, which is so generally thought necessary, is attended with the expected advantages.

Equal parts of the mordants, that is, half the weight of the stuff, produced no better effect than one-fourth; but between this quantity and one-twentieth part, the colours of cochineal, kermes, and madder, were weaker in proportion to the diminution of the quantity of the salts; whilst, on the contrary, the effects were reversed with woad and brasil wood, so that in these last substances the colour was deeper the more the salts were diminished. No difference could be observed in the colour, whether the wools had been in the alum bath for two, four, or six hours; it is, therefore, useless to continue stuffs in the bath longer than two hours. Our experiments did not discover that there was any difference in the colour, whether the dyeing took place immediately after the aluming, or was protracted for some time, except only that wool impregnated with alum alone, produced a deeper colour with woad, after having been exposed some time to a cool air, which we attributed to the separation of the acidulated sulphate of potash, this being carried off with the uncombined mordant in drying.

Of the Scarlet Colour.

Scarlet is that bright and shining colour which is produced in wool, by treating it with tartar, cochineal, and a highly oxidized solution of tin. Before the discovery of this method, for which we are entirely indebted to Drebbel, those colours were called scarlet which are produced in woollen stuffs by kermes or cochineal, when alum and tartar were employed as mordants. These processes for obtaining the colour have long been known in the dyeing houses, yet no theoretic investigations have been made into the phenomena which take place when a solution of tin is used with cream of tartar and cochineal. Dr Bancroft attempted to explain what passes in the formation of this colour; but as his opinion does not appear to be founded on any experiments, we considered the question as not at all determined by his labours. We propose, therefore, to determine the chemical nature of the combination formed upon wool by cochineal, tartar, and a solution of tin, and to make known the result of our inquiries upon the colour of scarlet.

Examination of the Precipitate formed by the Solution of Tin, and the Acidulated Tartrate of Potash.

All the substances employed by us in our experiments were perfectly pure, and we constantly made use of glass vessels and distilled water. Eighty grammes of acidulated tartrate of potash, dissolved in three kilogrammes and five * hectogrammes of distilled water, were macerated for two hours, at 100° (212° F.) of heat, with 125 grains of a solution of tin. The precipitate which we obtained was washed several times, and distilled in a

* About seven pints.

small curved retort, the beak of which being plunged into lime water, there was disengaged a sensible quantity of carbonic acid. Proper reagents indicated, in other portions of it, the presence of a great deal of tin and muriatic acid. Thus the cream of tartar and solution of tin are decomposed, and produce a precipitate, consisting of tartaric acid, and a great quantity of muriatic acid and tin. The mother water contains tartrate of potash, acidulated tartrate, very acid muriate of tin, and a considerable portion of precipitate, held in solution by excess of muriatic acid.

Very pure white wool, treated with the ordinary proportions of solution of tin and cream of tartar employed in dyeing scarlet, was washed a great number of times in boiling water, which carried off all the substances combined with it. These washings, collected and evaporated, afforded us the same principles we had before obtained from the precipitate formed by the solution of tin and cream of tartar: we also examined, in the same way, the action of cochineal, and found no difference in the results. From these facts we are, to a certainty, convinced, that the fine scarlet colour is produced by the wool being combined with colouring matter, tartaric acid, muriatic acid, and peroxide of tin. But we shall mistake, if we think the bath has no influence on the colour; for wool, combined with the mordants we shall presently mention, and dyed with cochineal, never takes the scarlet hue unless some acid be added, which causes the colour to pass from yellowish to red, and at length to a bright colour. This last experiment, and some others which we shall relate towards the close of this memoir, proved to us, that the wool is not coloured yellow by the combination it forms with the nitric acid in excess in the solution of tin, for this wool comes out perfectly white from all the boilings it undergoes with the tin, when no colouring matter is employed.

Of Tartrate of Tin, and some other Metallic Solutions.

The proofs we have already given of the formation of scarlet, appear to us so decisive, that we should not have thought of increasing the number, had not the importance of the question induced us to extend further our labours on this subject.

We tried upon wool, in the usual proportions for dyeing scarlet, all the sulphates and muriates of antimony, bismuth, zinc, arsenic. Some of these solutions afforded very agreeable colours, but very different from what we were seeking to obtain. We were more fortunate in our attempts with the tartrate of tin, obtained from tartrate of potash and soda, and a highly oxidized muriate of tin. This salt, dissolved in muriatic acid, and used in the operation of dyeing, afforded us a scarlet colour, as beautiful and bright as those obtained by cream of tartar and a solution of tin. The tartrate of tin, also, dissolved in an excess of its own acid, produced very good effects: however, as this method would be more costly than the ordinary processes, it is best to employ the solution of this salt in muriatic acid. But before recommending this mordant to be used in the dye-houses, we intend to make trial of it in the large way, so as to determine precisely the expense of it, and what advantages will be obtained by its employment.

Experiments on the Colour of Scarlet and the Oxides of Tin.

Scarlet, as we have already seen, is obtained by treating wool with determined proportions of cochineal, acidulated tartrate of potash, and a highly oxidized solution of tin. The operation of dyeing is divided into two parts; the first taking up an hour and a half, the latter half an

hour: this division is necessary to produce a good colour, which would be weaker and more yellow if all the substances were mixed in the first operation, and applied to the wool for two hours. This circumstance is owing to the very acid state of the bath, which holds in solution a great part of the mordant and of the colouring matter. We obtain the contrary effect when the mordants only are employed in the first operation, and the cochineal reserved for the second.

Pieces of very beautiful scarlet cloth, macerated in distilled water, at a boiling heat, gave out to the water a portion of their colour, and, when the operation was finished, appeared only of a light flesh-colour. The washings, collected and evaporated, were very acid, and contained, besides the colouring substance and animal matter, tartaric acid, muriatic acid, and oxide of tin. Scarlet, therefore, as we have already shown, is a combination in some measure soluble, which, in parting with a small quantity of acid, changes its shade, and may, by repeated washings at elevated temperatures, and with a large bulk of fluid, be rendered completely colourless.

It results from the experiments related in this memoir,—

1. That in aluming all vegetable and animal substances, it is not the alumina which combines with them, but the entire alum; and that, when these matters are not purified, the lime which they contain occasions a decomposition of a part of this mordant.

2. That all the alkaline and earthy bases, mixed with a solution of alum, decompose it, and convert it into acid sulphate of potash, and into an insoluble salt, less acid than alum, which may, by repeated washings, be converted into pure alumina, sulphate of potash, and alum.

3. That the acetate of alumina combines also in its entire state with silk, wool, cotton, and thread; that this

compound retains its acid but feebly, and loses a portion of it by simple exposure to the air; and that it is then changed into acid acetate of alumina, which is carried off by water, and into alumina which remains upon the stuffs.

4. That alum and tartar are not decomposed, but that the solubility of the latter is increased by the mixture; and that in impregnating wools either with tartar, or alum and tartar, the tartar alone is decomposed; that the tartaric acid and alum combine with the stuff, and tartrate of potash remains in the bath.

5. That the most powerful acids have the property, when combined with wool, of fixing the colouring matters; a property possessed in a high degree by the acid tartrate of alumina.

6. That alum and tartar cannot be employed indifferently for all colours, and that their proportions must depend upon the nature of the colouring matter; that the time of aluming should not be more than two hours, and that the exposure of the stuffs in a moist place, after the mordants are applied, is of no utility in augmenting the intensity of their colour.

7. That highly oxidized tartrate of tin, dissolved in muriatic acid, may supply the place of cream of tartar and the solution of tin in dyeing scarlet.

8. Lastly, That these experiments furnish some useful hints for combining mordants with the stuffs to be dyed, and for improving several of the processes of dyeing.

To complete these researches relative to the action of mordants, it would without doubt be necessary to determine, in the most accurate manner, the changes produced in these combinations by the colouring matters, when applied to the different stuffs.

Note C. p. 80.

Acetate of alumina is now most frequently made for the calico printers, by dissolving alum in a solution of crude acetate of lime (pyrolignite): a gallon of the acetate, of specific gravity 1.050, or 1.060, being used with $2\frac{5}{8}$ lbs. of alum. A sulphate of lime is formed, which precipitates, while an acetate of alumina, mixed with some alum, floats above. The specific gravity of this liquid is usually about 1.080. The acetate of alumina employed as a mordant for chintzes, is still commonly made by the mutual decomposition of alum and acetate of lead. Fifteen parts of alum are equivalent to about twenty-four of acetate. This proportion is somewhat more exact than that of 60 to 100, given in a footnote to page 80. vol. i.

Note D. p. 82.

See the figure and description of the padding or blotching machine in the Appendix.

The action of cow-dung in the process of calico printing, has not been hitherto completely analyzed. It probably seizes that portion of the mordant which is not intimately combined with the cloth, thus depriving it of the power of applying to the rest of the surface, when diffused through the water of the cleansing bath. Thus some animal principle in the dung, by neutralizing the excess of mordant, and possibly precipitating it in an insoluble or inert state, protects the unmordanted spaces from being stained or coloured.

Note E. p. 82.

See the figure, and explanation of the wash wheels, at the end of the volume. This mode of washing is by much the most economical and effective. Several other mechanical modes of washing are used in the linen trade.

Note F. p. 83.

Bran acts in some peculiar way on the colouring matter, but scarcely on the mordants. It seems to loosen and remove the colouring matter; as also to alter its hue in some cases, an effect obvious in the bran pinks.

Note G. p. 83.

The strength of the solution of chloride of lime for clearing calico grounds, varies according to the goodness of the white to be cleared, and the capability of the colour to bear it. From half a pound to a pound of the dry commercial chloride, for 100 gallons of water at 180° Fahrenheit, may be considered as an average proportion.

Note H. p. 86.

James Thomson, Esq. of Primrose Hill, F. R. S. obtained, in the years 1813 and 1815, two patents for certain improvements in calico printing. His processes, which are very elegant, have since been extensively and

advantageously employed. The following is an outline of his specifications. That for 1813 is thus stated:—

First, Mix or combine with the acid called oxymuriatic acid (or dephlogisticated acid of sea salt) and water, some of the alkaline salts or earths herein after-named, which shall weaken or suspend the power of the said acid in such proportion, that it shall not, in such mixed or combined state, of itself, and without any farther operation, be able to remove the turkey red colour from the cloth, or materially to impair it, within the moderate space of time taken up in the performance of the process herein after described.

Secondly, Print, stamp, pencil, or otherwise apply to those parts of the said cloth, which are intended to be either wholly, or in a greater or less degree, deprived of their red colour, some other acid or metallic oxide, or calx, which has a greater affinity or attraction for the alkaline salt or earth with which the oxymuriatic acid is mixed or combined, than that acid itself possesses: and if any one of the stronger or more powerful acids be employed, which is either of a corrosive nature, and cannot be safely used, or of a volatile nature, and cannot be used conveniently, such acid must be combined with alkalies, earths, metals, or metallic oxides or calces, so as to form neutral salts, acid salts, or metallic salts, which shall not be too corrosive or too volatile; and such alkalies, earths, metals, or metallic oxides, or calces only, must be employed, as have a weaker affinity or attraction for the same acid than that acid has for the alkaline salt or earth with which the oxymuriatic acid has been mixed or combined.

Thirdly, After the said acids, oxides, neutral salts, acid salts, or metallic salts, so directed to be printed, stamped, pencilled, or otherwise applied to the cloth as aforesaid, are sufficiently dry, immerse the cloth in the solution of the said oxymuriatic acid, so mixed or

combined with some of the alkaline salts or earths herein after-named as aforesaid. When the acid or oxide, either in its simple or combined state, has been applied to parts of the cloth, it immediately seizes upon and combines with the alkaline salt or earth with which the oxymuriatic acid has been mixed or combined, and disengages that acid, which almost instantaneously deprives of their colour those parts of the cloth to which the said acids or oxides, in their simple or combined state, have been so printed, stamped, pencilled, or otherwise applied as aforesaid.

Lastly, Wash or otherwise remove all the said acids, oxides, or salts, by the usual processes. For the more fully explaining and illustrating the invention herein before described, I add the following remarks:—The alkaline salts or earths which I mix or combine with the oxymuriatic acid, in order to suspend or prevent its action on those parts of the red cloth which are intended to retain their colour, are the alkaline salts of potash and soda, or the calcareous, magnesian, barytic, or strontitic earths, of which I prefer the calcareous earth.

The acids which I apply to the parts intended to be made white, or to those places on the cloth intended to be deprived of their red colour, in a greater or less degree, are any of the vegetable, mineral, or animal acids, which have a stronger attraction for the alkaline salt or earth with which the oxymuriatic acid has been mixed or combined, than that acid itself has; such, for instance, are the citric, oxalic, tartaric, malic, benzoic, sulphuric, sulphurous, phosphoric, fluoric, boracic, nitric, muriatic, arsenic, tungstic, succinic, and carbonic acids.

The stronger acids, or such as might corrode the cloth, I saturate more or less with some alkaline salt, earth, or metallic oxide or calx, for which they have a weaker affinity or attraction than they have for the alkali or earth with which I have combined the oxymuriatic

acid: for instance, I unite the sulphuric acid with potash, so as to form the acid sulphate of potash (or acid vitriolated tartar), or with aluminous earth, to form alum. The muriatic acid I combine with tin, or copper, or zinc, forming muriate of tin, muriate of copper, or muriate of zinc. In like manner, the nitric acid may be combined with the aluminous earth, or with the volatile alkali, or with the metals, or oxides of copper, or zinc, or iron, or mercury; and I take care, when I use acidulous compounds of such corrosive acids, not to suffer the acid so far to predominate as to render the compound injurious. In like manner, I combine the volatile acids, or such as might evaporate too speedily, with some alkaline salt or earth, or metallic oxide or calx, for which they have a weaker affinity or attraction than they have for the alkali or earth with which I have combined the oxymuriatic acid: for instance, I combine the acetic acid with the earth of alum, so as to form acetate of alumina,—or with copper, forming acetate of copper,—or with zinc, forming acetate of zinc. The carbonic acid may also be fixed and combined with an alkali, as with soda, for example, forming carbonate of soda, which may be used, though with less advantage than the preceding combinations. Those acids which are not corrosive nor volatile, and which consequently are used with most advantage in their simple or combined state, may, however, be united like the preceding to the alkalies, earths, metals, or metallic oxides or calces, for which they have a weaker affinity or attraction than they have for the alkali or earth with which the oxymuriatic acid has been united. Thus the tartaric acid may be combined with potash, to form cream of tartar,—and the oxalic acid with potash, to form salt of sorrel,—and these two salts may be employed in the process, though it is not necessary so to combine the two acids; but, on the contrary, the acids may be used alone.

The combinations which I prefer as uniting the greatest number of advantages upon the whole, are, the supersulphate of potash (or acid vitriolated tartar), the sulphate of copper or blue vitriol, the muriate of tin or sal jovis, the nitrate of copper, and the muriate of copper. But I prefer to any single combination a mixture of the supersulphate of potash, with the tartaric or citric acids.

Lastly, I employ, uncombined, such metallic oxides or calces as approach in their properties to the nature of acids, and are capable of combining either with the alkaline salts of potash or soda, or with the calcareous, magnesian, or strontitic earths, or of disengaging them, or any of them, from their combination with oxymuriatic acid: such, for instance, is the oxide of arsenic, or common white arsenic, and the oxides of tin and tungsten.

It is evident, from what I have set forth in the preceding part of this specification, that this process admits of great variety in its application, according to the combinations I make use of; since not only the various acids, oxides, and salts I have enumerated, may be employed, but also various mixtures of them, and in various proportions; but I prefer and generally use the following process:—

First, I take one gallon of good vinegar, or rectified pyroligneous acid, which I thicken with starch or flour in the way practised by calico printers, in preparing the mordants or colours for printing. Whilst boiling hot, I add to it five pounds of crystallized tartaric acid, and incorporate the whole very well by stirring.

Or, I take one gallon of strong concentrated lime-juice or lemon juice, or one gallon of water, in which I have dissolved two pounds and a half of crystallized citric acid, which I thicken with starch or flour in the manner directed above, and to which, whilst hot, I add two pounds of supersulphate of potash, and incorporate the

whole very well by stirring. I prefer starch to any other thickening, though others may be used with more or less advantage.

Secondly, The paste so prepared I print, stamp, pencil, or otherwise apply to the cloth previously dyed turkey red, in the mode and with the precautions generally used in the printing or stamping of linens or cottons.

Thirdly, I prepare a solution of oxymuriate of lime, either by dissolving the dry oxymuriate of lime (commonly called bleaching powder, or bleaching salts) in water, or by passing the oxymuriatic acid gas into a vat, vessel, or cistern, in which, by agitation or otherwise, I keep suspended such quantity of quicklime as will more than saturate fully and completely the said oxymuriatic acid gas. In either way, I obtain a solution of oxymuriate of lime, with excess of lime. That which I use and prefer is of the specific gravity 1050, and I seldom employ it lower than 1030 (water being considered as 1000). The vat, vessel, or cistern, which contains the solution of oxymuriate of lime, in which I immerse the cloths, may be of any size or form best adapted to the purpose or situation. I use and prefer vessels of stone of from six to eight feet deep, six to seven feet long, and three and a half to four feet broad; but larger or smaller vessels will answer very well.

Fourthly, When the cloths are ready for immersion, which they are as soon as the paste is dry, I hook them on a frame, such as is used in dyeing indigo or china blues, commonly called a dipping frame, on which the cloth should be so disposed that no two folds can touch each other. I then plunge the frame with the cloth so attached into the vat containing the solution of oxymuriate of lime, and keep it gently in motion during the time of immersion, which should not be prolonged more than ten minutes, and which rarely need exceed five minutes. The object being either wholly or partially to

remove the turkey red dye from certain parts or places, as soon as that is done the cloth should be withdrawn from the solution of the oxymuriate of lime, and plunged or rinsed in clean water. I practise and approve the aforesaid plan of immersion; but any other plan or plans by which the cloth can be exposed a greater or less time to the action of the oxymuriate of lime, without bringing one part of the said cloth into contact with another, will answer very well.

Lastly, After having, as before directed, rinsed or washed the cloths in clean water, I free them from all remains of the different agents or substances employed, by the ordinary means of washing, branning, or soaping, as practised by calico printers; and if those parts of the cloth that are intended to be made white, should still retain any red, or other tinge or stain injurious to the effect, in order to render the white complete, I clear it by the usual process of exposure to the air, or by passing the cloth through hot water, to which I have added as much of the solution of oxymuriate of lime as will remove the said stains or tinge, without material injury to those parts from which the red dye is not intended to be removed.

I then proceed, if other colours are to be applied to finish the cloths, by the ordinary and well known methods of calico printers; but these not being necessarily connected with, nor forming any part of the peculiar process or invention herein intended to be described, I purposely make no mention of here.

The above particulars and examples are given for the more full explanation of the said invention, and the manner in which the same is to be performed. But the invention, whereof I claim the sole and exclusive use, consists in printing, stamping, pencilling, or otherwise applying to those parts of the cloth which are intended to be either wholly, or in a greater or less degree, de-

prived of their red colour, an acid, oxide, neutral salt, acid salt, or metallic salt, such as is herein before for that purpose directed, and immersing the whole cloth in such mixture or combination of oxymuriatic acid and water, with some of the alkaline salts or earths, as is herein directed for that purpose.

Mr Thomson's patent for 1815, is specified as follows:—

The ordinary practice of calico printers is to apply, with the block or pencil, what are termed after-colours, to certain spaces, originally left in their patterns, and intended to receive the said after-colours; or to certain spaces on the cloth, from which parts of the original pattern have been discharged, in order to admit, by a subsequent operation, the application of the said after-colours. Now the object of my invention is, by one application of the block, cylinder, roller, plate, pencil, or other mode, to remove parts of the original pattern or colour from the cloth, and at the same time to deposit a metallic oxide, or earthy base, which shall of itself be a colour, or shall serve as a mordant to some colour to be produced, as herein after described.

First, Mix or combine with the acid called oxymuriatic acid (or dephlogisticated acid of sea salt) and water, the alkaline salts of potash or soda, or, which is still better, calcareous earth or quicklime, in such proportion as will weaken or suspend the power of the said acid, so that it shall not in such mixed or combined state, of itself, and without any further operation, be able to remove, or materially to improve the colours, within the moderate space of time taken up in the performance of the process.

Secondly, Print, stamp, pencil, or otherwise apply to those parts of the cloth which are intended to be deprived of one colour and to receive another, a solution of some earthy or metallic salt; the acid of which having

a greater affinity or attraction for the alkaline salt or earth with which the oxymuriatic acid is mixed or combined than that acid itself possesses, will disengage it, and the metallic or earthy base of which being deposited in the cloth, will either of itself be a colour, or serve as a mordant to some other colour, to be produced as herein after described.

Thirdly, After the metallic or earthy solution aforesaid has been printed, stamped, pencilled, or otherwise applied to the cloth, as before directed, and is sufficiently dry, immerse the cloth in the solution of oxymuriatic acid, combined with the alkaline salt of potash or soda, or, which I greatly prefer, with calcareous earth or lime, when the acid of the metallic or earthy solution which has been applied to parts of the cloth, will immediately seize upon and combine with the alkaline salt or earth with which the oxymuriatic acid has been mixed or combined, and disengage that acid, which will almost instantaneously deprive of their colour those parts of the cloth to which the said earthy or metallic salt has been applied.

Fourthly, Wash or otherwise remove the said acids or salts by the usual processes, and when the earthy or metallic base, deposited in the cloth, is intended to receive another colour, proceed to raise it by the usual operations of dyeing, as will be further illustrated in the examples hereafter given of particular applications of this invention. The earthy solutions which I apply to the parts intended to be deprived of their colour, and to receive another, are the solutions of alumina, or earth of alum in acids; such, for example, as the sulphate of alumina, or common alum, the acetate of alumina, or the nitrate or muriate of alumina. The metallic solutions which I employ are, the sulphate of iron or copperas; the nitrate, or muriate, or acetate of iron; the muriate of tin, or nitro-muriate of tin; the sulphate of copper or blue vitriol, or the nitrate, muriate, or acetate

of copper. All acids that form soluble compounds with the before-named metals, or the earth of alum, may be employed; but those only which form the most soluble compounds, such, for example, as those enumerated above, can be employed with advantage. For the more full and complete understanding of the principle laid down in the preceding part of this specification, I subjoin the following practical illustration of its application to various kinds of work. If I desire to have a yellow figure or stripe on the cloth, upon which a madder-red ground or pattern has been printed, after having, by the ordinary processes of calico printing, produced the red ground or pattern, I first print, stamp, pencil, or otherwise apply to those parts intended to be yellow, a strong aluminous mordant, composed of three pounds of sugar of lead, and six pounds of alum, dissolved in a gallon of water, and thickened with a due proportion of calcined starch, in the manner usually practised by calico printers.

Secondly, I prepare a solution of oxymuriate of lime, either by dissolving the dry oxymuriate of lime (commonly called bleaching powder, or bleaching salts) in water, or by passing the oxymuriatic gas into a vat, vessel, or cistern, in which, by agitation or otherwise, I keep suspended such quantity of quicklime as will more than saturate fully and completely the said oxymuriatic gas. In either way I obtain a solution of oxymuriate of lime, with excess of lime. That which I use and prefer is of the specific gravity 1050, and I seldom employ it lower than 1030 (water being considered as 1000). The vat, vessel, or cistern, which contains the solution of oxymuriate of lime in which I immerse the cloth, may be of any size or form best adapted to the purpose or situation. I use and prefer vessels of stone, of from six to eight feet deep, six to seven feet long, and three and a-half to four feet broad; but larger or smaller vessels will answer very well.

Thirdly, When the cloth is ready for immersion, which it is as soon as the paste is dry, I hook it on a frame, such as is used in dyeing indigo or China blues, commonly called a dipping frame, on which the cloth should be so disposed that no two folds can touch each other. I then plunge the frame, with the cloth so attached, into the vat containing the solution of oxymuriate of lime, and keep it gently in motion during the time of immersion, which rarely need exceed five minutes. The object being to remove the red dye from certain parts or places, as soon as that is done the cloth should be withdrawn from the solution of the oxymuriate of lime, and plunged into, or rinsed in cold water. I practise and approve the aforesaid plan of immersion; but any other plan, or plans, by which the cloth can be exposed a greater or less time to the action of the oxymuriate of lime, without bringing one part of the said cloth into contact with another, will answer very well.

Lastly, After having, as before directed, rinsed or washed the cloth in clean water, I free it from all superfluous remains of the different substances employed, by the ordinary means of washing, dunging, and cleaning, as practised by calico printers; after which I dye the cloth and raise the yellow in the usual way, with quercitron bark, or any other yellow dye.

If, instead of yellow, it is proposed to have a buff pattern or figure, I add to the aluminous mordant, prepared and thickened as above, one-fourth or one-sixth, or some intermediate proportion, of a solution of nitrate of iron, and proceed to print and immerse in oxymuriate of lime, as in the former case.

The red dye will be removed as before, and its place be occupied by a buff. If the buff be raised in quercitron bark, an olive will be obtained. By printing at separate times, and on different parts of the cloth, each of the above-mentioned mordants, both yellow and olive

figures on a red ground may be obtained. Similar effects, with trifling variations, take place, when, instead of red grounds, purple or chocolate grounds are employed; but it must be observed, that these colours being produced from mordants, consisting wholly, or in part, of solutions of iron, and the oxide of that metal not being removable by the process detailed in this specification, the after-colours produced will be modified more or less by the said oxide of iron. The foregoing examples are given for the more full explanation of the said invention, and the manner in which the same is to be performed; but the invention, whereof I claim the sole and exclusive use, consists in printing, stamping, pencilling, or otherwise applying to cloth, previously printed and dyed, or dyed any other colour than turkey red, any of the earthy or metallic solutions herein before for that purpose directed, and immersing the whole cloth in such mixture or combination of oxymuriatic acid and water, with some of the alkaline salts or earth, as is herein directed for that purpose, so as to remove the colour or pattern from the part so printed, stamped, pencilled, or receiving such application, and, by the same process, fix on such parts either a new colour or a mordant for a new colour.

Note I. p. 184.

James Lee, Esq. of Merton Abbey Flax-mills, obtained a patent in 1812, for preparing hemp and flax, without the process of steeping and dew-retting. He maintains, that when the hemp or flax plants are ripe, the farmer has nothing more to do than to pull them, as heretofore practised; to spread and dry them in the sun, as he would his hay or grain, taking care only in the ridges to lay the roots in one direction, so as to prevent

as much as possible the breaking or entanglement of the stems; and when sufficiently dry, to carry and lay them in store, either in ricks or barns. No preparation of a canal and running water; no loss of time; no hindrance from harvest, or other business, is necessary. Mr Lee seems not to have been happy in what relates to the machinery for breaking and manufacturing the flax and hemp prepared by his dry method. For an account of his mechanical contrivances, see some excellent papers on the Manufacture of Hemp and Flax, by John Mittington, Esq., inserted in the Quarterly Journal of Science, Literature, and the Arts, vol. iv. p. 321.; vol. v. p. 32.; vol. vi. p. 141.

Note K. p. 192.

In a foot note to page 62, I have adverted briefly to the mode of action by which chlorine destroys vegetable colours. Sir H. Davy first shewed that dry chlorine does not blanch dry litmus paper, but that when moisture intervenes the discoloration immediately takes place. When vegetable colouring matter, which consists of hydrogen, oxygen, carbon, and occasionally azote, (as in indigo), is placed in contact with chlorine and water, the elements react on one another, the greater part of the chlorine seizes the hydrogen to form muriatic acid, while some of it probably unites also with the carbon and hydrogen (and azote) of the colouring matter, so as to constitute a peculiar compound. The oxygen liberated from the water combines with the carbon, rendering it soluble in alkaline leys. The yellow-coloured substance resulting from the action of chlorine on moist vegetable colouring matter, has not, I believe, been subjected to any rigid ultimate analysis. Till this be done, the theory of bleaching by chlorine must be regarded as

imperfect. Of late years, quicklime has been very extensively and profitably employed by the Lancashire bleachers, as an alkaline agent.

Note L. p. 199.

In the Quarterly Journal of Science and the Arts for July 1822, I published a paper on the composition and manufacture of chloride of lime, where the proper proportions of the ingredients employed in its formation are investigated. "When a mixture of sulphuric acid, common salt, and black oxide of manganese, are the ingredients used, the absolute proportions are,

1 atom muriate of soda, -	7.50	29.70	100.00
1 atom peroxide of manganese,	5.50	21.78	73.30
2 atoms oil of vitriol, (1.846 sp. gr.)	12.25	48.52	163.30
	25.25	100.00	336.60

And the products ought to be,

Chlorine disengaged,	1 atom,	4.5	17.82
Sulphate of soda, -	1	9.0	35.64
Protosulphate of manganese,	1	9.5	37.62
Water, - -	2	2.25	8.92
		25.25	100.00

"These proportions are, however, very different from those employed by many, nay, I believe, by all manufacturers; and they ought to be so, on account of the impurity of their oxide of manganese. Yet making allowance for this, I am afraid that many of them commit great errors in the relative quantities of their materials.

"From the preceding computation it is evident, that one ton of salt, with one ton of the above native (impure)

oxide of manganese, properly treated, would yield 0.59 of a ton of chlorine, which would impregnate 1.41 ton of slacked lime, producing two tons of bleaching powder, stronger than the average of the commercial specimens; or allowing for a little loss, which is unavoidable, would afford two tons of ordinary powder, with a little more slacked lime."

I have lately analyzed two samples of recently made bleaching powder, made by two eminent manufacturers, one in Scotland, the other in England, and found the composition as follows:

Chlorine,	18.00	16.7
Lime, -	37.00	31.3
Muriate of lime,	28.50	29.0
Water, -	16.50	23.0
	100.00	100.0

The above quantity of lime is associated or mixed with the chlorine. The muriate of lime (chloride of calcium) is formed in the process, and is a product very disadvantageous to the manufacturer, since it takes up about one-half of his chlorine unprofitably, and adds a compound to his powder, probably injurious to the bleacher. Bleaching powder may be formed, which contains no appreciable proportion of the muriate of lime, as I have shewn in the above memoir. By proper management, the manufacturer of chloride of lime might therefore double his useful product at scarcely any additional expense.

Note M. p. 202.

For a description of a convenient apparatus for preparing dry chloride of lime, see the Quarterly Journal

of Science and the Arts for July 1822. In making the solution of chloride of lime or potash, the same arrangement of alembics may be adopted, but the chlorine disengaged must be conducted by lead pipes into large wooden vessels lined with lead, or constructed of masonry, which contain the mixture of lime or potash with water. The contents of this vessel or condenser are kept constantly agitated by means of wooden or iron vanes coated with lead, revolving on a vertical axis.

Note N. p. 212.

Sulphuret of lime, as proposed by Mr Higgins, was extensively employed for one or two years by the linen bleachers of Ireland. Their goods were, however, much injured by this article, whether from its injudicious use, or otherwise, I do not know. I have been told, however, that this compound has been recently tried in some establishments with advantage.

Note Q. p. 217.

The form of bucking tub (see the Plate at the end of the volume) now used in this country, is a simplification of Widmer's. It is found to answer perfectly well.

Note P. p. 226.

The introduction of the wash, dash, or splash wheel, of which a representation is given at the end of the volume, may be regarded as a very great improvement in the cotton manufacture of this country. Its velocity must be nicely regulated. When it is too slow, the

pieces of goods merely slide down the inclined planes of the partitions; and if too rapid, they are held stationary at the circumference by the excess of the centrifugal force. The proper speed is stated in the explanation of the plate.

Note Q. p. 241.

M. Welter, a practical chemist of deserved celebrity, states, that a given quantity of chlorine condensed in lime water destroys the colour of as much test solution of indigo, as if it had been condensed in pure water. Hence it would appear, that only chloride of lime is formed, and no muriate or chlorate, for the two latter salts possess no bleaching power; and had any of the chlorine been transformed into them, the discolouring force would have been proportionally impaired. Yet M. Chenevix, in his memoir on the hyperoxymuriates, or chlorates, obtained chlorates of lime and barytes by transmitting chlorine through solutions of these earths in water. Amid these conflicting opinions, it is difficult to decide. The analogy of solution of potash in its action with chlorine, is certainly favourable to the views of M. Chenevix. If the affinity of chloric acid for the bases be greater than that of acetic acid, then it would be possible to determine this point, by pouring vinegar on a determinate quantity of liquid chlorate of lime slightly heated. On M. Welter's theory, nearly the whole bulk of condensed chlorine would be recovered; but on Mr Chenevix's there would be a very considerable deficiency corresponding to the quantity of muriate and chlorate formed. A mixture of chlorate and muriate of lime, or of potash, neither of which has any bleaching power, would yield by heat as much oxygen as a pure chloride of lime, in whose formation a like quantity of chlorine

had been expended as in that of the above mixtures. Hence this mode of research, which has been recommended on respectable authority, is illusory, either for estimating the discolouring power of bleaching liquors or powders, or for analyzing these compounds.

Note R. p. 278.

In Robertson Buchanan's Treatise on the Management of Fuel, some useful directions will be found for applying steam to different processes of dyeing.

Note S. p. 311.

The just explanation of the phenomena which occur in the manufacture of sulphuric acid from the combustion of sulphur along with nitre, was first developed by MM. Clement and Desormes; and Sir H. Davy made some important observations on the subject. An outline of their view of this process is given in my Dictionary of Chemistry, article Acid (Sulphuric). It is a curious fact, that M. Berthollet was the only chemist of eminence who resisted the mass of evidence adduced by MM. Clement and Desormes in favour of their theory, which constitutes one of the most beautiful specimens of chemical research.

Note T. p. 331.

The reasoning in this paragraph about the union of muriatic acid with oxygen, to form oxymuriatic acid, is quite erroneous, and has been long since refuted by Sir H. Davy. A copious abstract of his experiments and investigations will be found in the article Chlorine of my Dictionary of Chemistry.

Note U. p. 333.

It is now known that the dry metallic muriates contain no oxygen, and no muriatic acid, but that they are compounds of chlorine with a metal; hence properly called chlorides. M. Berthollet's highly oxidized muriate (such as corrosive sublimate) contains no oxygen, but is a compound of two proportions of chlorine with one of mercury. M. Chenevix's oxygenated muriates are the chlorates of the present day, being compounds of chloric acid with a metallic oxide, or with ammonia.

Note V. p. 347.

This is a mistake. Acetic acid contains no azote.

Note X. p. 351.

By Klaproth's analysis, the alum ore of Tolfa consists of

Silica, - - - -	36.50
Alumina, - - -	19.00
Sulphuric acid, - -	16.50
Potash, - - -	4.00
Water, - - -	3.00
	99.00

Note Y. p. 355.

Alum is composed of

Sulphuric acid, - -	33.00
Alumina, - - -	11.00
Potash, - - -	10.00
Water, - - -	46.00
	100.00

The common alum of commerce, the potash-sulphate of alumina, requires about sixteen parts of water, at 60° F. to dissolve one of it; but there is another species, the soda-sulphate of alumina, soluble in less than its own weight of water, which on this account may become valuable in some processes of dyeing. For an account of this salt, see my Dictionary, article ALUM.

NOTE Z. p. 362.

A PROCESS in calico printing, of peculiar elegance, with an alkaline solution of alumina, was invented by James Thomson, Esq. of Primrose Hill, near Clithero. Its effect was to produce a fast green, by the mixture of a yellow mordant with the common solution of indigo in caustic potash, through the intervention of orpiment. This, as is obvious, could not be done with any acid solution of alumina. Mr Thomson first formed a solution of that earth in potash, mixed this with the solution of indigo, and applied the mixture, properly thickened, to the cloth. But as, in the ordinary dunging operation, the alkali would naturally wash away with it the greater part of the alumina, the goods before being dunged were passed through a solution of sal ammoniac. It is easy to perceive the *rationale* of what takes place. The potash on the cloth combines with the muriatic acid of the sal ammonia, and as the two substances set free (the alumina and ammonia) have no tendency to combine, the former remains precipitated on the cloth at its points of application.

It obtained currently, but very improperly, the name of Warwick's green, because Dr Warwick made and sold the solution of aluminated potash to the printers.

Note AA. p. 366.

There is no proposition better established in chemistry, than that the different oxides of the same metal are compounds of oxygen and the metal in definite proportions, of which the series is regulated by the proportion in the lowest term of oxidizement. The successive oxides contain oxygen amounting to two, three, or four multiples of that in the protoxide. M. Berthollet was very unfortunate in adopting the notion of indefinite combination, and scarcely pardonable for resisting with such obstinacy the great body of evidence incompatible with his hypothesis.

Note BB. p. 378.

Before verdigris is pressed into cakes, it is in the form of light blue acicular crystals of a silky lustre, which, by the action of water, are resolved into a soluble acetate and an insoluble subacetate of copper, the latter being decomposed by the action of cold water, which gradually changes it into a brown powder: whether it is thus totally resolved into oxide of copper, or whether it remains a sub-salt, has not been ascertained. Mr R. Phillips states the composition of the silky blue crystals as follows:—

Acetic acid,	28.30	1 atom.
Peroxide of copper,	43.25	1
Water, -	28.45	5

The green decomposable powder obtained by acting on the silky crystals with water, or the subacetate, consists of 50 acid + 160 peroxide of copper. There remains in solution a binacetate.

The following is Mr Phillip's analysis of French and English verdigris.

	French.	English.
Acetic acid,	29.3	29.62
Peroxide of copper,	43.5	44.25
Water, -	25.2	25.51
Impurity, -	2.0	0.62
	100.0	100.00

Phillip's Annals, No. 21.

NOTES

TO

THE SECOND VOLUME.

Note CC. p. 5.

Mr Braconnot published in the Annales de Chimie, vol. lxxxiv. a chemical examination of the husks of walnuts. The juice of the husks, examined by reagents, exhibited the following effects: It strongly reddened infusion of litmus. Solution of gelatin formed in it a slight precipitate, which he ascribed to tannin. Sulphate of iron gave the juice so deep a green, that it appeared black. No precipitation took place, even on standing some time, in consequence of the free acid found in the mixture, which is capable of imparting a fine grey to wool or silk. Oxalate of ammonia indicated the presence of lime. Nitrate of barytes produced no signs of any sulphate. Nitrate of silver acts on it in a manner well adapted to reveal the presence of the alterable hydrocarburet radical, for it produces a pretty copious precipitate, which quickly becomes coloured, while the silver resumes its metallic lustre from the action of the vege-

table substance on the oxygen of the oxide. The precipitate is then no longer soluble, but in part, in nitric acid, and leaves charcoal as a residuum. Alkalies change the juice to a deep red, and form in it precipitates that contain lime. Acetate of lead occasioned in the juice a whitish, flocculent, very copious precipitate, which dissolved entirely in distilled vinegar. From this precipitate, malic and citric acids were obtained. Subacetate of lead produced a new precipitate with the preceding liquid, and rendered the whole nearly colourless. This sediment yielded malic acid, colouring matter, and tannin. The magma left after expression of the juice, after having been treated with alcohol, which extracted from it some green resinous matter, was heated with water till it boiled, to free it from the starch and the coloured matter it retained. When thus exhausted, it was digested with dilute nitric acid, which separated some phosphate and oxalate of lime, that had been precipitated from the acid liquor by ammonia. The means employed to separate these two earthy salts, which are very frequently associated in vegetables, are founded on the property which distilled vinegar diluted with water has of dissolving phosphate of lime, without sensibly affecting the calcareous oxalate.

Though the husk has a peculiar smell, it afforded nothing remarkable by distillation in a water bath.

The incinerated ashes of the husk yielded potash, carbonate of lime, phosphate of lime, and oxide of iron.

From the above examination it appears, that the fleshy covering of the walnut contains:—

1st, Starch; 2d, An acid and bitter substance, very alterable, which appears to approach to the state of charcoal by the contact of air; 3d, Malic and citric acids; 4th, Tannin; 5th, Phosphate of lime; 6th, Oxalate of lime; 7th, Potash.

Note DD. p. 45.

Guatimala Indigo, treated first with water, then with alcohol, and lastly with muriatic acid, afforded to M. Chevreul, (Ann. de Chimie, vol. lxvi. p. 20.) the following products:—

By water,	A green matter united to ammonia, A little deoxidized indigo, Extractive, Gum,	12
By alcohol,	Green matter, Red resin, A little indigo,	30
By muriatic acid,	Red resin,	6
	Carbonate of lime,	2
	Red oxide of iron,	2
	Alumina,	3
A residuum,	Of silica,	3
	Pure indigo,	45
		100

This process might therefore be adopted in the laboratory, for procuring indigo nearly pure. But when we wish to obtain this colouring substance exempt from all foreign matters, it is better to employ the following method, which we owe to M. Chevreul. Five decigrammes of common indigo, in powder, are to be put into a crucible of platinum or silver, which is to be carefully closed, and placed over ignited charcoal. The indigo sublimes, and attaches itself in crystals to the middle portion of the crucible. Another method is, to take the solution of deoxidized indigo, made with a solution of sulphate of iron and lime, or alkali, to decant the clear solution, and expose it to the air. The indigo soon speedily absorbs oxygen, and becomes insoluble. When it is separated from the liquid, it must be washed first with dilute

muriatic acid, then with water, and lastly with alcohol. M. Roard used in this way muriatic acid and water, for purifying on the great scale the very impure indigos obtained from pastil.

In my paper on the ultimate analysis of vegetable and animal substances, which the Royal Society honoured with a place in their Transactions for 1822, the following are stated as the constituents of 100 parts of indigo: Carbon 71.37, hydrogen 4.38, oxygen 14.25, azote 10. Or, carbon 71.37, water (or its elements) 16, azote 10. But the examination of indigo having been undertaken about the same time by my ingenious friend, Mr Walter Crum, I relinquished the subject. His paper on indigo, drawn up 1822, and published in the Annals of Philosophy for January 1823, must be regarded as the most elaborate and accurate analysis yet given of this interesting vegetable product. "For procuring indigo perfectly pure, I used," says he, "the covers of two platina crucibles, nearly three inches in diameter, of such a form, that, when placed with their concave sides inwards, they were about three-eighths of an inch distant in the middle. I placed thinly about the centre of the lower one ten grains of precipitated indigo, not in powder, but in small lumps of about a grain in weight; then, having put on the cover, I applied the flame of a spirit-lamp beneath the indigo. In a short time this substance, partially decomposed, begins to melt, and the purple vapour to be disengaged, which is known by the hissing noise that accompanies it. The heat is continued till this noise nearly ceases, when the lamp is withdrawn, and the apparatus allowed to cool. Then, on removing the cover, the sublimed indigo will be found planted upon its inner surface, with sometimes a few long needles upon the bottom of the apparatus, which are easily removed from the button of coaly matter that remains. In this way I have generally obtained eighteen to twenty per cent of the

indigo employed; a small quantity unavoidably escapes, but I am persuaded that very little more can, by any means of this kind, be obtained.

"Those who cannot readily procure precipitated indigo for the purpose of subliming, may find it convenient to combine with my method one lately given in the Journal de Pharmacie, by MM. Le Royer and Dumas. It consists in spreading about 30 grains of common indigo in coarse powder upon an open silver capsule, and applying the heat of a spirit-lamp till all the sublimed indigo is formed upon the surface of the ashes. On repeating this process, I find that ten parts of common indigo yield one of sublimed indigo, which is, however, far from being pure. By resublimation in my apparatus, it is again reduced one-half from the loss of its impurities, and some vapour.

"I shall here describe what else takes place during the sublimation. Ten grains of precipitated indigo, in the apparatus I have described, yielded

1.88 grain of sublimed indigo.
6.44 grains of cinder remained, and consequently
1.68 grain of volatile matter escaped.

10.00

"Thirteen grains of the same indigo, kept a quarter of an hour at a strong red heat in a small platina crucible, firmly, though not exactly closed, left 7.9 grains of cinder, which is equal to 61 per cent.

"In order to ascertain what gases were evolved during this destruction of the indigo, I introduced 5.28 grains into a small glass tube connected with a mercurial trough. On applying the heat of a spirit-lamp, the vapour of indigo was formed, and condensed in the colder part of the tube, but was at last destroyed by repeated applications of heat. A quantity of water appeared in the tube, and

0.96 cubic inch of gas was found in the receiver. On removing the tube, it was found to have lost in weight 0.71 grain, or 13.5 per cent of the indigo employed. The water that was formed had a disagreeable burnt ammoniacal smell. I found, on analyzing the gas in the receiver, (making allowance for the common air of the apparatus, and a small portion of gas remaining in the tube), that it consisted, for 100 of indigo, of

Carbonic acid, - - - -	2.8
Carburetted hydrogen and carbonic oxide,	0.8
Azote, - - - - -	1.9
The difference between the sum of these and the loss 13.5 was water, with a little ammonia,	8.0
	13.5

Sublimed Indigo.

"Indigo sublimes in long flat needles, which readily split, when they are bruised, into four-sided prisms.

"Viewed at a particular angle, they have the most brilliant and intense copper colour; but when lying in heaps, they have a rich chestnut-brown colour; one that would be produced by mixing a very little yellow with a bright but deep reddish purple.

"Besides these needles, this substance is found in the form of plates, much broader than the needles, and extremely thin; twisted sometimes almost into tubes. These appear to the naked eye perfectly opaque. I was not a little pleased, however, with their unexpected appearance, when seen through the microscope. Viewed obliquely, they appear still opaque, and copper-coloured like the needles; but when held perpendicularly to the rays of light, they are seen to be transparent, and of a beautiful blue colour, exactly similar to a dilute solution of indigo which has been acted upon by sulphuric acid.

Their intensity varies, according to the thickness of the plate, from a blue just distinguishable from white, to one almost black. The bronze colour which these crystals assume when in heaps, is obviously a mixture of the copper colour with this blue.

"The vapour of indigo is transparent, and of a most beautiful reddish violet colour, resembling a good deal the vapour of iodine, but sufficiently distinguished from it by the shade of red. The sublimation takes place at the heat of about 550° Fahrenheit; for the vapour rises at a heat lower than that of melting lead, and requires more than the melting heat of bismuth. Upon the rough bright surface of the lead, I observed some of the crystals melt while the vapour was rising; but I have in no other circumstances remarked any thing like fusion, till the substance was decomposed. Hence the melting point of indigo, its point of volatilization, and that at which it is decomposed, are remarkably near each other.

"The specific gravity of sublimed indigo is 1.35.

"These crystals sublime when heated in open vessels, leaving no residue. In close vessels, the vapour is at first reddish-violet, as in the open air; but as the heat advances, it acquires a tinge of scarlet; and before it is entirely decomposed, becomes deep scarlet, and then orange-coloured: a quantity of charcoal is at the same time deposited.

"*Action of Oils.*—Of the essential oils, oil of turpentine dissolves at its boiling heat as much indigo as gives it the fine violet colour of the vapour of indigo; but a slight reduction of temperature is sufficient to precipitate the whole of it. The fixed oils and fatty substances, as they may be heated to a higher degree, exert a more powerful action upon indigo. None of them that I have tried act upon it at the heat of boiling water; but when the heat is increased, they gradually dissolve it, acquiring the colour of its vapour much more deep than oil of tur-

pentine does. If the solution be cooled at this period, the indigo precipitates blue. As the heat is continued, more of the indigo is dissolved; but the colour of the solution begins to change; it gradually inclines to crimson, and has then begun to be destroyed. It is now green when cooled. Heated still more, the solution is of a strong crimson; then becomes orange; and at last, when entirely decomposed, it is yellow, which colour it retains when cold.

Determination of the Ultimate Constituents of Indigo.

Carbon, - - - - - -	73.22
Azote, - - - - - -	11.26
Oxygen, - - - - - -	12.60
Hydrogen, - - - - -	2.92
	100.00

These numbers correspond very nearly to

1 atom of azote, - -	1.75 or	10.77
2 atoms of oxygen, - -	2.00	12.31
4 atoms of hydrogen, - -	0.50	3.08
16 atoms of carbon, -	12.00	73.84
	16.25	100.00

"I have also made several analyses of well-dried precipitated indigo; and allowing for a minute portion of sulphate of lime which it contained, I got results which agreed perfectly with the analyses of sublimed indigo. I find too, that both these substances are acted upon in the same manner by other bodies. The different effect of heat depends obviously upon some difference in the mechanical arrangement of their particles.

"I made several attempts to amalgamate sublimed indigo, as well by the process of Dobereiner, as by others

which I thought more likely to succeed, but in vain. I could in no case perceive the least alteration in the fluidity of the quicksilver.

Action of Sulphuric Acid upon Indigo.

"When indigo is digested in concentrated sulphuric acid, it is well known to suffer a remarkable change, being converted into a peculiar blue substance, entirely different from indigo, with which the Saxon blue is dyed.

"This substance has been so little attended to by chemists, that no one has yet thought of giving it a separate name. I shall venture to propose for it that of *cerulin*, from the colour of its solution.

"The mixture of the blue substance with sulphuric acid is a semifluid, which requires a considerable quantity of water to dissolve it. When potash is added to this solution, previously filtered, a deep blue precipitate is formed. I was surprised, however, when making the experiment, to find the precipitate as plentiful before one-fourth of the acid was saturated, as when the solution was made altogether neutral. To another portion, I added potash previously saturated with sulphuric acid, and found the same precipitate formed as with potash alone.* I threw the precipitate upon a filter, and washed it with water, in order to examine whether it was the pure colouring matter that had separated. The first

* That the solution of indigo in sulphuric acid is precipitated by neutral salts, is not a new fact. Berthollet (Art of Dyeing, ii. 50.) says, that the "fixed alkalis saturated with carbonic acid," as well as "alcohol, saturated solutions of alum, sulphate of soda, or other salts containing sulphuric acid," form precipitates in this solution. My experiments show, I think, that the effect does not depend upon the presence of sulphuric acid in the precipitant; that some sulphates have no such effect; and that alcohol does not precipitate the original solution at all.

washing did not take away much of the precipitate; the next, however, sensibly diminished it; but with the third portion of water, it almost wholly disappeared.

"In order to discover the cause of this increased solubility, I made a saturated solution of sulphate of potash in water, and, putting into it a little of the blue pulpy substance that remained upon the filter, I agitated it thoroughly. The solution remained altogether colourless. I found the same to be the case when the muriate, the acetate, or any other salt of potash, was employed. Alcohol also, and ether, refused to dissolve this substance. Put into pure water, however, it immediately dissolved, forming the same deep blue solution that had passed through the filter.

"It seemed then only necessary to dissolve in water some salt of potash, to enable it to wash this substance without dissolving it. I found the acetate to answer extremely well; and this salt possesses the advantage over the muriate or sulphate of not being precipitated by alcohol from a weak solution in water, as they are. It may consequently be afterwards removed by washings with alcohol.

"Such edulcorations with acetate of potash I repeated so often upon a quantity of precipitate, taking it every time off the filter and agitating it well in a phial with the liquid, that not $\frac{1}{5000}$th of a grain of the original soluble matter could be left in it. I then washed away the weak solution of acetate of potash as well as possible by means of alcohol, without, however, being able to remove all traces of that salt, although I used the alcohol somewhat dilute. The small quantity that remained could not materially affect the experiments I made upon it.

"A portion of the substance thus prepared, when burnt in a large platina crucible, left a considerable quantity of ashes, slightly reddish-coloured, which dissolved almost entirely in water. What remained was of a deep red,

or rather brown colour, and was principally oxide of iron. The solution of the ashes was not at all alkaline: it gave a dense white precipitate with muriate of barytes; a very slight one with oxalate of ammonia; and with sulphate of alumina, large crystals of alum were formed in a few hours. It was sulphate of potash.

"From these facts, I have no hesitation in concluding, that this precipitate is a combination of cerulin with sulphate of potash. That salt forms more than a fourth of its weight. It may, therefore, be called *ceruleo-sulphate of potash.*

"The salts of soda also form precipitates in the solution of cerulin with sulphuric acid, and these are likewise insoluble in solutions of potash or soda, though soluble to a certain extent in pure water. When heated, these ceruleo-sulphates dissolve even in solutions of their salts. On cooling, the greater part falls down again in blackish grains; a portion, however, remaining in solution. The soda compound is evidently more soluble than that of potash. The washings of the former precipitate, with a cold solution of its acetate, are a little more coloured than those of the potash precipitate, with its acetate of the same strength. This last substance is totally insoluble in water containing one per cent of acetate of potash, or even a half per cent after two or three edulcorations. I have generally employed a solution of two parts dry acetate of soda in a hundred of water; and any quantity of such a liquid may be used without the quantity of the substance being materially diminished.

"The salts of ammonia likewise form precipitates in the sulphuric solution of cerulin, when not much diluted. The precipitate dissolves readily in hot solutions of ammoniacal salts, and again separates when cold, the whole mass becoming curdy. I believe this substance to be a combination of cerulin with sulphate of ammonia, from the quantity of that salt which I found in it, when as

well washed as possible. It is much more soluble, however, than the ceruleo-sulphates of potash and soda, and therefore cannot be washed so freely as these fixed alkaline compounds. Potash and soda, and their salts, decompose it. It dissolves in great quantity in boiling pure water, and in 40 or 50 parts of cold water. It has the same general properties with the more insoluble compounds.

"A corresponding combination with barytes may be formed by decomposing ceruleo-sulphate of potash by muriate of barytes. The compound formed is extremely insoluble. An abundant blue precipitate is thus formed in solutions of ceruleo-sulphate of potash, containing so little sulphuric acid, that they are not troubled in the slightest degree by a barytic salt, when the cerulin has been previously destroyed by nitric acid.

"Similar compounds may be formed with other bases, whose sulphates are difficultly soluble in water; but these I have not particularly examined.

"The salts of magnesia have no power of precipitating cerulin from its solution. The whole of the sulphuric acid in the original solution may be saturated with magnesia, without any precipitate being formed.

Ceruleo-sulphate of Potash.

"This substance is of so deep a blue, when wet with water, as to appear absolutely black. When dry, it has a shining strong copper-red colour. By transmitted light it is blue. It attracts water from the air with great rapidity. In two hours, a portion which had been dried attracted a tenth of its weight.

"It is soluble to a considerable extent in hot water. Cold water takes up $\frac{1}{140}$th of its weight of this substance, and forms a solution so deeply coloured, that when diluted with 20 parts of water in a phial of an inch in dia-

meter, it may just be seen to be transparent. Water in a wine glass containing $\frac{1}{500.000}$th of its weight of this substance is distinctly blue coloured.

"The saturated solution is precipitated by spring water, and by every liquid that I have tried, except distilled water. From this it appears, that the mere presence of any foreign substance in pure water greatly diminishes its solubility.

"If the solution be diluted with 20 parts of pure water, it is still precipitated by solutions of the salts of potash and soda, lime, barytes, strontian, lead, and mercury. An addition of sulphuric or muriatic acid does not redissolve them. But neither ammonia nor any of its salts precipitate this weak solution. None of the salts of magnesia, zinc, or copper, nor the solutions of alum, sulphate of manganese, permuriate of tin, protosulphate or persulphate of iron, or nitrate of silver, precipitate it. It is not precipitated by any of the acids, by infusion of galls, or by pure gelatin. Alcohol and ether do not precipitate the weak aqueous solution, though they do not dissolve any of the dry substance. Ceruleo-sulphate of potash dissolves readily in concentrated sulphuric acid, but not in concentrated muriatic acid.

"When chloride of tin is mixed with the solution of this substance, its colour is immediately changed to yellow. This yellow product is not very soluble in water; it becomes blue again on the addition of any substance, as a salt of copper, capable of imparting oxygen to it.

"When heat is applied to the blue substance, it does not melt; no purple vapour is given off, and in consequence of its being defended by the saline matter, a strong heat long applied is necessary for its being reduced to ashes.

"When luminous objects, as the sun or moon, or the flame of a candle, are viewed through the blue solution

of this substance, of the proper degree of intensity, they appear of a fine rich scarlet colour. It is worthy of remark, that a single drop of nitrate or sulphate of copper, mixed with a quantity of this solution, makes the same objects appear blue through it, although the general appearance of the liquid is not in the least degree altered. Zinc produces the same effect, though not so powerfully. Any acid restores to these mixtures the property of making luminous objects appear red, unless when a large quantity of copper has been added, which makes the liquid itself green.

"Sir H. Davy was the first to discover that a vegetable substance had the power of precipitating in combination with certain neutral salts, which are themselves abundantly soluble in water. The carbonates of potash, soda, and ammonia, and the chlorides of tin and of iron, are among the substances which that philosopher found undecomposed in combination with tannin, in the precipitates formed by these salts in an infusion of galls. It appears that cerulin acts a similar part, at least with the sulphuric salts. I am not aware, however, that any substance has been hitherto described by chemists which possesses the property I have found in the one here treated of, that of dissolving in pure water, and refusing to do so in neutral saline solutions which produce no change upon it. But in common life, some idea of this singular fact seems to have been long acted upon. Those who are in the habit of washing printed gowns, particularly dark ones, of colours not very permanent, always rinse them in a solution of common salt, or at least in very hard water, before they hang them up to dry. The salt, they say, fixes the colour, and prevents it from spreading out into the white, which it always does when they are suffered to dry in a cool place, without such immersion.

On the Phenomena which are exhibited during the Formation of Cerulin.

"Some of the phenomena which attend the action of sulphuric acid upon indigo, have been noticed by different chemists. Bergman, in 1776, observed, that when indigo in powder was sprinkled upon sulphuric acid, greenish clouds were produced, which became blue by the addition of a drop of water. He added, that the same effect was produced, but more slowly, without water. Hausmann, of Colmar, observed, that the acid in contact with indigo became at first greenish-yellow, then deep green, and at last blue. That gentleman remarked also, that the "effervescence and disengagement of sulphurous vapours, always observed in making the blue compound, leave no room to doubt that the acid exerts an action upon the particles of indigo, and that we should be wrong in considering this as a mere solution of indigo unaltered." Berthollet, in his excellent work on Dyeing, considers the change that takes place a species of combustion; the sulphuric acid furnishing the indigo with oxygen, and thereby being converted into sulphurous acid. Dr Bancroft, whose work appeared soon after that of Berthollet, conceived the solution to be oxygenated indigo combined with sulphuric acid. Hence he gave it the name of sulphate of indigo.

"Such, as far as my information goes, is the extent of our knowledge, or rather our opinions, upon this subject. I shall state what appearances I have myself observed during this process.

"When indigo is put into sulphuric acid, it is dissolved, and the acid assumes a yellow colour. When this solution is dropped into water, it becomes instantly blue; but the substance so produced is by no means the same as that which is formed after some time, without the

assistance of water. It is indigo altogether unchanged, which precipitates, and leaves the sulphuric acid perfectly colourless. If the yellow solution be exposed to the open air in a watch glass for a short time, the blue colour is restored in the same manner, and the indigo falls down. This effect is produced, not by the action of the air, but merely by the absorption of moisture.

"A considerable increase of heat takes place when the two substances are put together. There can be little doubt that this is caused by the sulphuric acid abstracting and combining with the 14.2 per cent of water contained in the indigo.'

"If the yellow solution above-mentioned be allowed to remain without dilution, it becomes blue in a few hours; and this is effected without the assistance of air, as I found by making the experiment in a small phial, the mouth of which was sealed up as soon as the materials were put together. In consequence of the darkness of the liquid, these changes of colour can only be observed in the thin film which wets the empty part of the phial, when it is agitated.

"All the chemists who have treated of this process, mention the formation of sulphurous acid during the solution of indigo, and, attributing this to the action of the indigo itself upon the acid, they naturally concluded that that substance became oxidated at the expense of the acid. But these chemists employed only the indigo of commerce in their experiments; a substance which contains more than half its weight of impurities, and great part of these vegetable matter. I have found that it is these impurities alone which decompose the acid; for during the solution of sublimed indigo not a trace of sulphurous acid can be detected, though the heat of boiling water be applied for hours. Neither is there any production of hyposulphuric acid; for, if there were, it would be decomposed by the heat to which the liquid

was exposed, or even by the presence alone of concentrated sulphuric acid, in which case sulphurous acid gas would be given off.

"In less than 24 hours, if a slight degree of heat be applied, the indigo is entirely converted into cerulin; and, when mixed with water, it passes through the filter, leaving no residue whatever.

On the Constitution of Cerulin.

"Since there is no production of sulphurous acid, nor absorption of air, during the formation of cerulin, it is clear that there can be no oxidation either of the carbon or hydrogen previously existing in the indigo. No carbon being deposited, and no gas evolved, during this process, prove also that the azote exists in the new substance, in the same proportion to the carbon that it does in indigo. That sulphuric acid does not enter into its composition, is evident from its precipitating with almost any sulphuric salt, and carrying down no additional sulphuric acid of its own. It is only in the amount of combined water, then, that any alteration can possibly have taken place; and to ascertain whether in this case there has been an abstraction or an addition of water to the indigo, it were only necessary to convert a given weight of that substance into cerulin, and to weigh the product, as M. de Saussure has done in the case of starch sugar. There are difficulties, however, which prevent such an experiment from being performed with any precision; principally the large quantity of sulphuric acid necessarily mixed with the product, and the solubility of the substance in water. I have contented myself with analyzing, by means of peroxide of copper, the ceruleo-sulphate of potash, after having ascertained as nearly as possible, by incineration, how much saline matter it contained. But, as this cannot be done with absolute precision, owing to

the dissipation of a small portion of acid along with the vegetable matter, my results, particularly with regard to the hydrogen, were by no means so uniform as those which I obtained when operating upon indigo. All that is really necessary in this case, is to determine the quantity of carbon, which may be done with very little risk of error. The deficiency, after adding to the carbon the proportion of azote, and of free hydrogen found in indigo, is water.

"The ultimate composition of the substance is:

Carbon, - - -	57.18
Azote, - - -	8.79
Oxygen, - - -	29.32
Hydrogen, - - -	4.71
	100.00

This approaches so near to *indigo* + 4 *water*, that there can be little doubt such is its constitution.

1 atom azote, -	1.75	or	8.43
6 atoms oxygen, -	6.00		28.92
8 atoms hydrogen, -	1.00		4.82
16 atoms carbon, -	12.00		57.83
	20.75		100.00

"There is not the slightest proof that any combination exists between cerulin and sulphuric acid in the original liquid. Alkalies, it is true, precipitate it from the solution; and this has been supposed to be the effect of a superior attraction on the part of the acid for the alkali, by which the vegetable substance was left at liberty; but such a theory falls to the ground as soon as it becomes known that neutral salts produce exactly the

same effect; that magnesia does not precipitate it at all, though it neutralizes the acid; and that cerulin is itself soluble in water. Cerulin dissolves, indeed, in sulphuric acid, and that more abundantly than in water; but this does not argue the formation of a compound which we are entitled to call sulphate of indigo. Such a solution differs in no respect from that of resins and other organic bodies in the same acid, or even from the solution of these substances in alcohol or ether.

"Those who are fond of speculating upon the manner in which the elements of water are arranged in organic bodies, may find it curious that sulphuric acid should abstract water from indigo, and not from cerulin, a substance which contains three times as much oxygen and hydrogen; or that the same acid which robs indigo of its water, should immediately restore three times as much.

On a new Substance produced from Indigo by means of Sulphuric Acid.

"While engaged with these experiments, I discovered, that if the action of sulphuric acid upon indigo be stopped at a certain point, a new substance, altogether different from cerulin, is produced, possessing rather singular properties. It is formed at the instant that indigo changes from yellow to blue by the action of sulphuric acid.

"By the following process, it is obtained of greater purity than by any other method I have been able to discover. Prepare a quantity of indigo by boiling it in sulphuric acid diluted with three parts of water, and drying, after it is well washed. By such treatment, it is deprived of more than a third of its weight of impurities. Mix one part of this purified indigo with seven or eight parts of concentrated sulphuric acid in a stoppered phial, and agitate the mixture occasionally, till it becomes of a bottle-green colour. Then mix it with a large quantity

of distilled water, and throw it upon a filter. By continuing to wash the filter with distilled water, the liquid which at first passes through colourless becomes more and more blue, and after some time, all the indigo which has been changed, passes through. The colourless washings must be thrown away. The blue liquid contains the new substance in solution, and does not differ in appearance from a solution of cerulin. On the addition of muriate of potash, the new substance precipitates of a most beautiful reddish-purple colour, exactly similar to the colour of the vapour of indigo. Let this precipitate be thrown upon a filter, and washed with distilled water, till the liquid which passes through forms no longer a whitish, but a red precipitate with nitrate of silver. It may then be dried.

"From the property possessed by this substance of becoming purple-coloured on the addition of a salt, I have called it *Phenicin*, from the Greek word φοῖνιξ, purple, and, to prevent circumlocution, I shall hereafter make use of this term.

"This substance, prepared with muriate of potash, is, when dry, of a brownish-black colour. Heated in a crucible, it gives off a little vapour of indigo. I was at first uncertain whether this might not proceed from indigo formed by the decomposition of part of the phenicin by the heat; but I shall state a fact which shows that the indigo may have another source, and that it may exist in a small quantity in the purple substance. After the filter is washed, till the washings are very slightly blue-coloured, the liquid that passes through is precipitated blue, instead of red, by muriate of potash, and the precipitate consists of indigo with a little phenicin. Thus it appears that even indigo is, in certain circumstances, capable of dissolving in water. By drying the phenicin, prepared as I have stated, and redissolving it, a small

quantity of indigo remains; but still the phenicin yields a little purple vapour when heated.

"When the purple substance is burnt, it leaves about fifteen per cent of ashes, which dissolve in water, and consist of sulphate and muriate of potash.

"Phenicin dissolves both in water and alcohol, and the solution in both cases is blue. It is precipitated again of its original purple colour by all saline substances whatever. Different salts, however, possess different powers of precipitation. Thus muriate of ammonia, chlorate and prussiate of potash, and muriate of soda, precipitate the phenicin entirely from about sixty times their weight of any aqueous solution; and nitrate, muriate, and sulphate of potash, from about 100 times their weight. But the sulphates of magnesia, zinc, and copper, precipitate 2000 times their weight of a solution of phenicin; sulphate of iron about 3000 times; and alum and muriate of lime as much as 8000 times.

"The phenicin being previously combined with a salt of potash, is not altered by being again precipitated by any alkaline salt. These salts do nothing more than saturate the water to such a degree, that the substance is no longer capable of dissolving in it. But the earthy and metallic salts combine with this substance, and displace the salt of potash previously united with it; and I have observed very little difference in the quantities necessary to precipitate solutions of different strengths. The precipitates formed by lime, barytes, alum, and copper, are totally insoluble in pure water, however well they may be washed. Those formed by iron and magnesia dissolve to a small extent, when freed from their former menstrua by filtration. Their solution is purple-coloured.

"Acids have no effect in preventing the precipitation of phenicin by saline bodies; and the precipitates once formed are not redissolved in the same liquid by the assistance of heat.

"The method which I have given for preparing the new substance is tedious. As only a small part of the indigo is converted into phenicin, the quantity obtained each time is very small, and requires a great quantity of distilled water, and a long time to filter. But if we allow the indigo to be wholly converted into phenicin, its solution cannot be made to pass through any filter, however porous, or however well washed it may have been with water or ammonia. It was by accident that I discovered the possibility of filtering it when only a small portion of the indigo had had time to be changed; and it was only by preparing it in this manner that I found the purple colour to be owing to the presence of saline matter, and its own colour to be like that of cerulin.

"The following is a method of preparing this substance in greater quantities, though not so pure. Mix together one part of indigo in powder, and ten parts of concentrated sulphuric acid, in a phial, and agitate from time to time, till the blue colour, which the indigo loses at first, is completely restored. This, at the ordinary heat of summer, requires nearly three hours. At 100° Fahr. it is effected in about twenty minutes; and indigo mixed with sulphuric acid, at the heat of boiling water, becomes blue the instant the mixture is made. At 45° Fahr. ten or twelve hours are necessary; and at lower degrees of heat, a still longer time, supposing always the quantity of materials small enough to cool very soon after mixture to the stated point. Pour this mixture into a large quantity of distilled water, and filter. Take the precipitate off the filter, wash it well with distilled water, containing the proportion of muriate of ammonia necessary to prevent the substance from dissolving in it, and filter again. Dissolve anew the precipitate in a large quantity of distilled water; heat the solution to drive off any particles of air which might prevent the impurities from subsiding, and let it stand two or three days in a tall vessel.

Then draw off with a syphon as much as may be thought perfectly clear, leaving the remainder to be washed with more distilled water. Add to the solution any alkaline salt, till the substance be precipitated; then throw it upon a filter, and wash with distilled water till the liquid refuses to pass through.

"When a solution of phenicin is precipitated, the liquid that remains is always more or less coloured with cerulin; and however often this be repeated upon the same material, a little cerulin is always left. If it has been heated, more cerulin is formed. It follows from this, that phenicin is changed into cerulin by the action of water alone.

"Phenicin dissolves in the water of liquid ammonia without injury; but the fixed alkalies destroy it, though not very readily. Chloride of tin precipitates the solution, but gradually redissolves the precipitate, forming a yellow solution; and the phenicin is thrown down again of its own colour, by the salts of copper.

"Phenicin dissolves readily in concentrated sulphuric acid, forming a blue solution; and if this be poured immediately into water, the greater part of it is precipitated again, the impurities of the acid being sufficient to prevent its solution in water. A portion is converted into cerulin, which remains in solution. When allowed to remain dissolved in sulphuric acid, it is soon entirely converted into cerulin; consequently, in preparing phenicin by the second process, it is impossible to prevent the formation of a certain portion of cerulin.

Constitution of Phenicin.

"The facts which I have stated to prove that cerulin differs from indigo only in containing more or less water, equally apply to this substance.

"One grain of pure phenicin produced 5.085 cubic inches of dry carbonic acid gas, which contain 0.6462 grain of carbon. Hence, calculating as in the case of cerulin, the substance consists of

Carbon, - - - -	64.62
Azote, - - - -	9.91
Oxygen, - - - -	21.49
Hydrogen, - - - -	3.98
	100.00

"This is very nearly *indigo* + 2 *water*, and its atomic proportions may be thus stated:

1 atom azote, - -	1.75 or	9.46
4 atoms oxygen, - -	4.00	21.62
6 atoms hydrogen, -	0.75	4.05
16 atoms carbon, - -	12.00	64.87
	18.50	100.00

"The experiments of Mr Smithson, related in the Philosophical Transactions, have given us very correct ideas on the nature of a number of the vegetable colouring matters. It is sufficiently obvious that phenicin is not the principle which colours any of the purple or blue vegetables examined by that chemist. I collected a number more of such purple flowers as are most commonly met with, and dipped them separately in concentrated sulphuric acid. But instead of becoming blue, they were uniformly changed to red, and formed red-coloured solutions on the addition of water. Future inquiries, therefore, must determine whether phenicin exists ready formed in nature either in the blue or in the purple state.

"Alcohol modifies remarkably the action of sulphuric acid upon indigo. A mixture of three parts of alcohol, of specific gravity 0.84, and two parts of acid, dissolves indigo without rendering it yellow, and the solution may even be filtered through strong paper. Probably a larger quantity of pure alcohol might be employed. On the addition of water, the indigo is precipitated without alteration; and if common indigo has been used, resin precipitates along with it. It may remain dissolved in this mixture any length of time without conversion into phenicin. A solution of phenicin in sulphuric acid may also be mixed with alcohol without precipitation, and the acid is rendered incapable of converting it into cerulin."

Mr Holt states, that the solution of indigo in sulphuric acid is completely deprived of colour, by adding to it filings of zinc or iron. Whenever the colourless, or slightly grey-coloured solution, suffers the contact of air, the blue colour reappears. It was previously well known that sulphuretted hydrogen blanched the above solution of indigo.

Note EE. p. 61.

A valuable paper on the cultivation of woad in England, was published by Mr John Parrish, in the 12th volume of the Letters of the Bath Agricultural Society. It is reprinted in Tilloch's Magazine, vol. xxxviii. p. 43.

Note FF. p. 145.

The first person who established, in this country, a factory for dyeing the Adrianople madder-red, was M. Papillon, who, in the year 1790, obtained a premium from the Commissioners and Trustees for Manufactures

in Scotland, for communicating the details of it to Dr Black, on condition that it should not be divulged for a certain term of years, during which M. Papillon was to have the sole use of his own secret. The term being expired, the process was published. It resembles pretty closely the method described in the text by M. Berthollet. Those who wish to compare them, will find M. Papillon's in the 18th volume of Tilloch's Magazine, p. 43.

M. Vitalis, in his valuable treatise on dyeing, published in 1823, *(Cours Elémentaire de Teinture)*, has entered at considerable length into the description of the Turkey red dye, with which his situation at Rouen had made him familiar. I shall here note those points in which he appears to differ from M. Berthollet, or is more precise.

In the *second* operation, he states, that from 25 to 30 pounds of sheep's dung are commonly used for 100 pounds of cotton yarn. The dung is first steeped for some days in a ley of soda, of 8° to 10°. This is afterwards diluted with about 500 pints of a weaker ley, and at the same time bruised with the hand in a copper basin, whose bottom is pierced with small holes. The liquor is then poured into a vat containing five or six pounds of fat oil *(Gallipoli)*, and the whole are well mixed. The cotton is washed in this, as prescribed by M. Berthollet. The hanks of cotton yarn are then stretched on perches in the open air, and turned from time to time, so as to make it dry equally. After receiving thus a certain degree of desiccation, it is carried into the drying house, which is heated to 50° Reaumur (144° Fahrenheit), where it loses the remainder of its moisture, which would have prevented it from combining with the other mordants, which it is afterwards to receive. What is left of the bath is called *avances*, and is added to the following bath. Two, or even three dung baths, are given to the cotton, when it is wished to have very rich

colours. When the cotton has received the dung baths, care must be taken not to leave it lying in heaps for any length of time, lest it should take fire; an accident which has occasionally happened.

Third Operation.—Oil or White Bath.

This bath is prepared by pouring in six pounds of fat oil, fifty pints of soda water, at 1° or sometimes less, according as, by a preliminary trial, the oil requires. This bath ought to be repeated two, three, or even a greater number of times, as more or less body is to be given to the colour.

Fourth Operation.—Salts.

To what remains of the white bath, and which is also styled *avances*, about 100 pints of soda ley of two or three degrees are added. Through this the cotton is passed as usual. Formerly, it was the practice to give two, three, or even four salts. Now two are found to be sufficient.

Fifth Operation.—Degraissage.

The cotton is steeped for five or six hours in a tepid solution of soda, of 1° at most; it is set to drain, is then sprinkled with water, and at the end of an hour is washed, hank by hank, to purge it entirely from the oil. What remains of the water of *degraissage*, serves for the scouring or *first* operation.

Sixth Operation.—Galling.

For 100 pounds of cotton, from twenty to twenty-five pounds of galls in sorts must be taken, which are bruised and boiled in about 100 pints of water, till they crumble

easily between the fingers. The galling may be done at two operations, dividing the above quantity of galls between them, which is thought to give a richer and more uniform colour.

Seventh Operation.—Aluming.

The aluming of 100 pounds of cotton requires from twenty-five to thirty pounds of pure alum, that is, alum entirely free from ferruginous salts. The alum should be dissolved without boiling, in about 100 pints of river or rain water. When the alum is dissolved, there is to be poured in a solution of soda, made with the sixteenth part of the weight of the alum. A second portion of the alkaline solution must not be poured in till the effervescence caused by the first portion has entirely ceased,—and so in succession. The bath of saturated alum, being merely tepid, the cotton is passed through it, as in the gall bath, so as to impregnate it well, and it is dried with the precautions recommended above. The dyers who gall at two times, alum also twice, for like reasons.

Eighth Operation.—Washing away the Alum.

Ninth Operation.—Maddering.

For twenty-five pounds of cotton, twenty-five pints of blood are prescribed, and 400 pints of water. Whenever the bath begins to warm, fifty pounds of madder are diffused through the bath. Sometimes the maddering is given at two operations, dividing the madder into two portions.

Tenth Operation.—Brightening.

The brightening bath is prepared always for 100 pounds of cotton, with from four to five pounds of rich

oil, six pounds of Marseilles white soap, and 600 litres of soda water of 2°.

Eleventh Operation.—Rosing.

This is done with solution of tin, mixed with soap water.

Two systems for the Turkey red are known at Rouen. The first is called the grey course, the second the yellow; (*marche en gris*, and *marche en jaune*).

The *grey* course takes its name from the cotton being subjected to the maddering immediately after it has received the oily preparations, and the mordants of galls and alum, which give it a *grey* colour.

The *yellow* course is so called, because in this system the cotton, after having received a first time the oily preparations, as well as the mordants of galls and alum, is *not* exposed to the maddering till it has passed a second time through the same preparations and the same mordants, which gives it a yellow colour. It is this second manner of working the Turkey red, which is called, in the phraseology of the dye-house, *remounting on the galls.*

The following table exhibits the difference which exists between these two courses:—

Grey Course.	*Yellow Course.*
Boiling	Boiling
Dung baths	Dung baths
White baths	White baths
Salts	Salts
Degraissage	*Degraissage*
Galling	Galling
Aluming	Aluming
Washing off the alum	Washing off the alum
Maddering	White baths
Brightening	Salt

Grey Course.	*Yellow Course.*
Rosing	Degraissage
	Galling
	Aluming
	Washing off the alum
	Maddering
	Brightening
	Rosing.

The grey course, as well as the yellow, is susceptible of a great many combinations and varieties, both in the order and number of the operations, relative to each. The following are some examples with developments, which cannot fail to interest dyers.

Grey Course for 100 *pounds of Cotton.*

Scouring in a soda liquor at $1\frac{1}{2}°$, or with the waters of *degraissage* at 2°.

Dung bath, with 25 pounds of dung, and six pounds of oil—stove-drying.

Dung bath,—idem—drying—idem.

White bath, with five pounds of oil, and soda liquor, at 1°, $1\frac{1}{2}°$, or 2°—drying.

White bath,—idem—drying.

One or two salts, the first at 2°, the second at 3°—drying.

Degraissage in pure water, of a temperature equal to that of the atmosphere in summer, and between 15° and 18° Reaumur (66° and 72° Fahr.) in winter. The cotton is kept in the water for an hour or two. It is then taken out, wrung at the jack, and dried.

White bath, as above.

White bath, idem.

White bath, idem.

Degraissage, as above, with this difference, that it is washed well before wringing, and then dried.

First galling, with seven pounds of galls in sorts, or galls of Istria—drying.

Second galling, with 14 pounds of sumach, which is just brought to boil; it is then refreshed (with cold water), passed through a sieve, and the cotton is turned through as hot as possible—drying.

First aluming, with 13 pounds of purified alum; it gets next a slight washing, but is not dried.

Second aluming, with 12 pounds of the same alum—thorough washing—wringing—no drying.

Maddering, with seven quarters of a pound of Provence lizari for every pound of cotton. Only 25 pounds are dyed at a time, which must be allowed to cool after coming out of the boiler before it is washed; then it is to be wrung, but not dried.

Brightening, with soda liquor at $1\frac{1}{2}°$, or with what remains of the water of *degraissage*; to which three or four pounds of white soap may be added. The cotton must be boiled for four or five hours in a copper closed with a cover, but not so tight as to hinder the steam from escaping. The ebullition is to be kept up, till a pattern, which has been observed from time to time, has reached the proper point. The cotton is allowed to cool in the boiler, is then well squeezed, washed in the river, wrung at the jack and pin, and, without drying, subjected to the next operation.

Rosing, with 12 pounds of white soap, dissolved in a sufficient quantity of water. When the soap is dissolved, there is poured into the copper a solution of a pound or a pound and a half of salt of tin in two pounds of lukewarm water, to which about a third of a bottle *(bouteille)* of nitric acid at 36° of the areometer has been added. It is made to boil for four or five hours, and the cotton is withdrawn whenever a pattern has attained the proper hue.

If the first rosing do not bring the cotton to the desired tint, a second similar to the preceding may be given; but only eight pounds of soap should be employed.

Yellow Course, in like manner, for 100 *pounds of Cotton.*

Scouring, as in the grey course.

Two baths of sheep's dung, each along with five or six pounds of oil—drying.

Two white baths, each with six or eight pounds of oil —drying.

Two salts, each at 2° of the *pèse liqueur* of Baumé.

Degraissage, as usual—washing—then drying.

First galling, with eight pounds of nut-galls—drying.

First aluming, with 13 pounds of pure alum—washing without drying—wringing, and drying.

Three white baths, each with six pounds of oil—drying.

Two salts, each at 2°—drying.

Second galling, with four pounds of galls, and 12 pounds of sumach—drying.

Second aluming, with 13 pounds of pure alum—drying.

Washing off the alum very carefully—wringing—drying or not, at pleasure.

Maddering, with two pounds of lizari of Provence per pound of cotton.

Brightening, as in the grey course.

First rosing, as in the grey course.

Second rosing (if wanted), as in the grey course.

The system of operations indicated in either of the above courses, appears to M. Vitalis so preferable to every other, that he wishes dyers to follow them, leaving them always at liberty to give baths a little more charged with oil, more of them, or some additional salts, &c.

The grey course is usually followed for making the ordinary Adrianople reds; and the yellow course is reserved for reds of the first quality, in point of lustre and durability.

It is also by the yellow course that linen or hemp must be treated.

M. Vitalis states, in his *Manuel du Teinturier*, that the bisulphate of potash may be used instead of the salt of tin for rosing, and that it gives to the red a peculiar shade very agreeable to the eye. In vain, he observes, should we attempt to give a fine red with only 25 pounds of oil for 100 of cotton. No less than 40 pounds are employed, and very commonly 50, or even more. Nor will sumach replace the galls; nor will a lower heat answer in the drying stove.

The *avances* (residuary liquors) in which the cotton has been worked after the galling, are good for nothing, and must be thrown away. When the Adrianople red is finished, the colour is much improved by preserving the cotton for one or two months shut up pretty tight in hempen bags. This seems to shew that the mordants have not completely exhausted their action in the operation itself, and that the affinities between them and the colouring matter requires a certain time to produce their whole effect.

A good Adrianople red supports for ten minutes the action of nitric acid at 18° of the areometer, without suffering any sensible change. By letting it remain longer in the acid, or by employing a stronger one, the cotton becomes more and more orange, and finally loses its colour. The simple madder reds, exposed to the same test, disappear in less than three minutes.

Cottons which have not been suitably worked in the preparations, come out of the maddering with a thin colour, sometimes of a brick hue. Before brightening these cottons, they ought to get new oil baths, and the

operation should be repeated as if they had not been dyed. The brightening and rosing will have a little less power than in ordinary cases. Cotton dyed Turkey red is sometimes too much charged with oil, and the excess rises in time to the surface of the cotton, or of the stuffs made from them. The surface is then sprinkled with small white points, which alter the beauty of the colour. This inconvenience is remedied by dipping the cotton for some time in, or by passing it or the stuffs through, a hot bath of soap. Ten or twelve pounds are sufficient for 100 pounds of materials.

Cotton yarns for warp being more twisted than those for woof, require more manipulation to give them an equally good colour.

The object of the scouring, or first operation in the Turkey red process, is to free the substances to be dyed from an oily or resinous matter, which envelopes their fibres, and fills the interstices between their filaments. It is this oily or resinous matter which renders these substances less white, and which weakens their affinity for water, and for the colouring matters which they are to receive. The baths of sheep's dung have been supposed to make the cotton or linen fibres approach more to the nature of animal substances. This albumino-gelatinous matter, dissolved in the alkaline ley of soda, is in the most favourable state for entering into combination with the cotton.

The white baths, which follow those of dung, co-operate with the latter, giving to the cotton the oily principle, for which cotton is known to have a great affinity, and which moreover enjoys the property of combining with the colouring matter.

But the superfluous quantity of oil, diffused merely on the surface of the fibres, would obstruct the assumption of the dye, and is therefore to be removed by the *degraissage*; an operation much more important than is

commonly imagined, and which therefore requires to be conducted with every possible care.

The washings have in general the same object as the *degraissage*, and require the same attention.

As to the desiccation, which must be performed after the greater part of the operations, its necessity will readily be recognized, by considering that the moisture introduced into the cotton by the application of a first mordant, would necessarily become an obstacle to the introduction and combination of a subsequent mordant. For this reason it is not sufficient always to dry in the air, but the desiccation must be completed in a stove heated to 50° or 55° Reaumur (144° to 156° Fahr.), especially during winter, and when the weather is moist.

It will be impossible to give a good explanation of the process of galling till the principles furnished by the nut-galls be more exactly known. It appears certain that they contain a peculiar acid, named from them the *gallic*. But what is the nature of the tannin which always accompanies that acid? The galls probably form not only an energetic mordant, by operating directly on the cotton which has received the oily preparations, but also act by attracting the alumina.

The alum plays a very important part in Turkey red dyeing, but its functions are not altogether explained. Some drops of the decoction of galls poured into a solution of alum determine, according to the late Mr Henry, a precipitate of a white colour, which appears to be alumina separated from the sulphuric acid. When galled cotton is passed through a solution of alum, it may therefore be supposed that a portion of the alumina is attracted to the cloth by the agency of the galls. The temperature of aluming ought to be rather low, viz. 18° or 20° Reaumur (about 75° Fahr.), since, at a greater heat, the alumina might be too rapidly and abundantly thrown down, and much of what is so hastily deposited

might not combine with the galls. This compound of galls and alumina forms a complex mordant, which unites with the mordants that the oily principle and the dung have already furnished.

We may also remark, that it is not without reason that, in the aluming for Turkey red, the precaution is taken of adding to the ordinary alum a certain quantity of alkali (an ounce of soda to about a pound of alum). Perhaps the oily baths contribute to the fixation of the alumina, forming with this earth a species of aluminous soap, so much the more permanent, as it is altogether insoluble in water. But the alkali must not be caustic, as Macquer had conjectured; for alumina, dissolved from alum in a caustic ley, will not answer for furnishing a mordant to the Adrianople madder-red. The blood adds no colouring matter to the madder in the dyeing operation. The dull and dark red which the cotton takes in the maddering is by no means an agreeable shade. This sombre hue must be removed from it, and a bright decided red brought out. This effect is obtained by the brightening, which lays bare the red tint that had been masqued by a brown colouring matter, which is dissolved and carried off by the brightening bath.

By the *rosing*, the cotton acquires a lustre and vivacity far superior to what the *brightening* can give. To obtain this effect, the cotton is set to boil for four or five hours, as has been stated, in a solution of white soap, to which a solution of the salt of tin (muriate) is added, along with a certain quantity of nitric acid, at 36° of the areometer. It would seem that in this operation the soap and the salt of tin mutually decompose one another,—that the muriatic, as well as the nitric, which are added, seize the soda constituent of the soap,—that the oil separated from the alkali unites to the oxide of tin to form an acid metallic soap, whereby the red is finally brightened, acquiring that lustre so pleasing to the eye.

The following process is that followed by a practical dyer of Turkey red in Scotland, for 1 cwt. of cloth or yarn.

First boil the goods with white soap and pearl ash, or soda ley. Twelve pounds of white soap are dissolved in water in a copper, along with six gallons of the ley, pretty strong. The boiling is continued for five or six hours.

2d, The sheep's dung liquor. To make this, take twelve gallons of soda liquor, No. 3. (sp. gr. 1.015), two gallons Gallipoli oil, six gallons sheep's dung, twenty-four gallons soda liquor, No. 5. (sp. gr. 1.025).

Tramp the cloth or yarn well in this liquor, then hang it in the air to dry, and next in the stove.

This dunging is repeated a second and a third time as above, drying the goods after each repetition.

The yarn or cloth is to be steeped all night in warm water, at 100° Fahr. with four gallons of soda liquor, No. 12. (sp. gr. 1.060). Out of this it is to be well wrung next morning, hung in the air, and, lastly, dried in the stove.

Take now twelve gallons of weak soda liquor, No. 3. (sp. gr. 1.015), Gallipoli oil, two gallons, soda liquor, No. 5. (sp. gr. 1.025), thirty gallons. Tramp the cloth or yarn in this mixture three or four times. Then put in the air, and finish in the stove every time.

Steep for clearing away the Oil.

Steep the goods in warm water at 140° Fahr. with four gallons of soda liquor for each cwt. Wring it out next morning, wash well and dry it, when it is ready for the galls.

Gall Liquor.

Take twenty-four or twenty-five pounds of nut-galls, and boil them for eight hours. Take the clear liquor,

and tramp the cloth or yarn as warm through this liquor as the skin can bear; wring, put in the air, and then in the stove.

Alum Liquor.

Take twenty-five pounds of alum,—dissolve in warm water; add four gallons of soda, No. 12. (sp. gr. 1.060). Next morning take the clear liquor, put it into a copper, and warm it as hot as the hands can bear. Tramp the stuff through this liquor, wring, and put in the stove to dry.

Second Aluming as above.

Steep the alumed goods in lukewarm water all night, next day wash them well in the river, then they are ready for drying.

To Dye twelve dozen of Cloths, (Pieces).

Allow two pounds of madder to each pound of cloth, bring to the boiling point in an hour, and keep boiling for half an hour. Then enter the goods into the copper, adding two gallons of blood well mixed. (The blood should surely be added to the cool, or merely tepid water.) Let the goods be now well washed and dried. For the *cue*, take half soda and half pearl ashes, half a gallon of oil, add as much water as will bring the liquor to No. 6. of the hydrometer, (sp. gr. 1.030). But the oil must have been previously mixed with twelve gallons of soda liquor, No. 3. (sp. gr. 1.015). Put the goods through this liquor as through the white bath; wring and stove-dry.

For Clearing.

Fill a copper with clean water; dissolve four or five pounds of white soap in it, and half a pound of pearl

ashes. Boil slowly from six to eight hours; then wash and wring the goods. Lastly, fill a copper with clean water, adding a pound or two of white soap, and boil the goods an hour or two.

They are now finished.

Mr John Thomson of Glasgow published in the Annals of Philosophy, vol. viii. p. 463. some ingenious ideas on the theory of the Turkey red process.

"Silk and worsted," says he, "have a natural varnish which cotton does not possess. To supply this defect, the repeated immersions, followed by exposure to the atmosphere, and to the heated air of a stove, may give the oil the proper consistency, by the absorption of oxygen, for forming a varnish, with which the colouring matter unites, and through which it may be said to shine, which causes that superior brilliancy which the goods attain when they are cleared, or, as it may be called, polished. I therefore presume, that the fixedness and brilliancy of the colour will depend on the quantity of oil imbibed, as every repetition of drying presents new fibres to be varnished with an additional quantity; for I have always found, that the permanency was in proportion to the number of manipulations in the saponaceous liquor, and a proportionable freedom could also be used in reducing or clearing. The white immersions, omitting the sheep's dung, are just applying successive coats of varnish. Clearing is never attempted from the madder copper, without immersing the goods again in soda and oil, and drying them in a stove, which I consider to be also supplying them with an additional coat.*

The alkaline ley occasions a greater separation in the particles of the oil, by which it combines more closely with the fabric of the cloth. The sheep's dung in the

* In the French processes given above, the brightening follows the maddering without any intermediate oil steep.—*Translator.*

first immersions may serve as a covering or great coat, to keep the goods moist for a considerable time, that they may more fully imbibe the liquor, by preventing the evaporation from being too quick in the great heat to which they are exposed.

After the frequent immersions the cloth feels like leather, no doubt from a superfluity of liquor. It is then steeped in a ley of carbonate of soda, and afterwards well washed and dried, as a preparation for the galling and aluming. The astringent principle has been long known for darkening and fixing common red colours on cotton, by uniting with the earth of alum, and strengthening the basis. To the use of blood in the madder copper I attribute nothing; as in the rancid and putrid state in which I have seen it used, were it not for the prejudice of the operator, it might be safely dispensed with.

In proof of the above idea, that it is only the oil uniting with the earth of alum that is of use, I may refer to the mode of dyeing that colour in the East, quoted by Dr Bancroft, viz. soaking their cotton in oil, (no matter of what description*), during the night, and exposing it to the sun and air during the day, for seven successive days, rinsing it only in running water, and then immersing it in a decoction of galls and the leaves of sumach previous to aluming.

I would therefore request the practical dyer, who wishes to arrive at a knowledge of this unaccountable process, to give up the idea of animalization, if by it be meant impregnating the cloth with an animal matter, and by the power of the microscope, or any better method, look for the whole truth from some other source than chemical analysis. I am at present inclined to

* Olive oil, hog's lard melted, oil of sessamum, &c. have all been used with success.

believe that it is a mechanical operation united to a chemical, and that the frequent immersions in the imperfect soap are equivalent to laying on the first, second, third, &c. coats, preparatory to finishing a fine painting in oil.

A very eminent calico manufacturer, whom I consulted on the Turkey red process, assured me, that the only essential mordants are oil and alumina; and that bright and fast reds, equal to any produced by the usual complicated process with sheep's dung, galls, and blood, may be obtained without these articles.

Dyeing Cotton of a Smoke-red (rouge enfumé).

Smoke-red is a name given to a dull red without lustre, which resembles the burned red *(rouge brulé)* of the India handkerchiefs. To dye this colour, the following method will answer.

1. Preparations of the Adrianople red, according to the grey course above prescribed, down to the maddering, inclusive.

2. The cotton, when washed and dried, receives a strong mordant of acetate of alumina; that is to say, at 6° of the areometer of Baumé, and at a temperature of about 70° Fahrenheit. After this it is dried, and then it receives a good washing.

3. It is passed through a bath of quercitron of greater or less strength.

4. After being dried and washed, it is brightened in a soda liquor with soap.

Dyeing Cotton of a Cherry and Rose-red.

The cherry-red is pretty certainly obtained by following the process which we shall point out.

Boiling.

Bath of sheep's dung.

Three white baths, each with 6 or 8 pounds of oil.

A salt at 2° Baumé.

A careful *degraissage*.

Galling with a decoction of 5 lbs. of nut-galls, to which the infusion of 20 lbs. of sumach is added.

Aluming with 36 lbs. of very pure alum.

Careful washing away of the alum.

Maddering with the madder of Cyprus or Smyrna, in the proportion of a pound or pound and a-half for every pound of cotton. There may, however, be mixed in, a third of Provence madder, with two-thirds of the above madders. Brightening, by boiling the cotton for five or six hours in a ley of soda, at 1½° Baumé, in which from 8 to 10 pounds of soap have been dissolved. The cotton is allowed to cool in the bath, and then washed. (The brightening may be also very simply effected, by passing the cotton through a weak solution of chloride of potash or lime.)

Rosing. The cotton is boiled during half an hour in six pints of water, in which has been dissolved a pound and a-half of salt of tin, pouring in afterwards a bottle (quart) of sulphuric acid, at 30° Baumé. On coming out of the boiler it is washed with care, then boiled anew, for three quarters of an hour, in a solution containing from 15 to 16 pounds of white soap.

For procuring the rose colour, the strength of the brightening is a little increased, and there is employed in rosing somewhat more sulphuric acid at first, than there is white soap in the succeeding bath.

The brightening in the oxygenated liquor suits well here. The rose may also be given, by using oily preparations not so highly charged, less mordant, and consequently less madder, in the dyeing bath.

A little experience will remove all obstacles.—*Vitalis.*

Note GG. p. 154.

We are indebted to MM. Pelletier and Caventou for a chemical investigation of cochineal, in which its colouring matter was skilfully eliminated. Their principal researches were directed to the mestèque cochineal (*coccus cacti*), though a few experiments were also made on some other kinds.

Purified sulphuric ether acquired by digestion with it a golden yellow colour. This infusion left, on evaporation, a fatty matter of the same colour.

Cochineal, exhausted by ether, was treated with alcohol at 40°. After thirty digestions in the apparatus of M. Chevreul, the cochineal continued to retain colour, although the alcohol had ceased to have any effect on it. The first alcoholic liquors were of a red verging on yellow. On cooling, they let fall a granular matter. By spontaneous evaporation, this matter, of a fine red colour, separated, assuming more of the crystalline appearance. These species of crystals dissolved entirely in water, which they tinged of a yellowish-red. Treated with very strong alcohol in the cold, they redissolved, leaving a very animalized brownish matter, to which we shall afterwards return, since we shall find this matter in greater abundance in the watery decoctions of cochineal previously exhausted by ether and alcohol.

The alcoholic solution of these crystals, thus deprived of its animalized matter, is still susceptible of affording the above crystalline sediment. In this state, although free from animalized matter, especially when they have been redissolved and recovered anew, these crystals do not, however, present the colouring matter pure, as was at first believed. If this matter be treated with sulphuric ether, one portion is dissolved and colours the ether orange-yellow; and it is only after the ether has ceased

to have any action on the mass, and when it comes off colourless, that the substance which will not dissolve in the ether may be regarded as the colouring principle, if not absolutely pure, at least very nearly so. The colouring principle of cochineal, insoluble by itself in ether, may, however, be dissolved in small quantity in this liquid through the intervention of the fat crystallizable matter, while the latter becomes less soluble in ether, as it is enveloped and protected by a quantity proportionally greater of the colouring principle. These considerations led MM. Pelletier and Caventou to make the following experiment, in the hope of stripping the colouring matter of every particle of the fat substance. They dissolved a certain quantity of their coloured crystals in very strong alcohol, and added a quantity of sulphuric ether equal to that of the alcohol employed. The mixture became turbid, but at the end of some days it had grown perfectly clear. It was of a red colour inclining considerably to yellow. A good deal of the colouring matter had, however, fallen down on the bottom of the vessel, forming an incrustation of a magnificent purple-red. This matter, treated with ether, no longer yielded any principle; and the properties to be presently detailed lead to the belief, that it may be regarded as the colouring matter of cochineal in a state of purity. By adding new portions of ether to the decanted liquor, a certain quantity of colouring matter may again be thrown down. The alcoholic tinctures in which the first crystals were formed, were evaporated to dryness on the water-bath; and the colouring matter obtained, treated by methods analogous to the preceding, afforded likewise fat crystallizable matter and colouring principle.

Of the Colouring Principle of Cochineal.

This matter has a very brilliant purple-red colour; it adheres strongly to the sides of the vessels; it has a

granular and somewhat crystalline aspect, very different, however, from those compound crystals alluded to above; it is not altered by the air, nor does it sensibly attract moisture. Exposed to the action of heat, it melts at about the fiftieth degree Centigrade (122° Fahr.) At a higher temperature it swells up, and is decomposed with the production of carburetted hydrogen, much oil, and a small quantity of water, very slightly acidulous. No trace of ammonia was found in these products.

The colouring principle of cochineal is very soluble in water. By evaporation, the liquid assumes the appearance of syrup, but never yields crystals. It requires of this matter a portion almost imponderable to give a perceptible tinge of bright purplish red to a large body of water. Alcohol dissolves this colouring substance, but, as we have already stated, the more highly it is rectified, the less of it does it dissolve. Sulphuric ether does not dissolve the colouring principle of cochineal, but weak acids do, possibly owing to their water of dilution. No acid precipitates it in its pure state. This colouring principle, however, appears to be precipitable by all the acids when it is accompanied by the animal matter of the cochineal.

Acids, however, change the colour of this substance, converting it into a bright red, then a yellowish-red, and lastly, a yellow. When the acids have not been too concentrated, its proper colour may be restored by saturation with alkali. Chlorine changes the colour of this principle to yellow, and then destroys it altogether. It produces no precipitate in its solution, unless it contains animal matter. Hence chlorine becomes a useful reagent for trying the purity of this colouring substance. Iodine acts like chlorine, but more slowly. The alkalis, poured into a solution of the colouring principle of cochineal, change its hue to crimson violet. If the alkali be immediately saturated, the original colour is restored, and the colouring matter may be recovered without any remark-

able alteration in its principal properties. If the action of the alkali has been longer continued, or aided by heat, the violet shade disappears, and the colour passes back to red, and then yellow. In this case, the colouring matter is totally altered, for by putting it into contact with those metallic salts which form with it insoluble combinations, we obtain precipitates entirely different from those which the pure colouring matter produces with the same salts.

Lime water produces a violet precipitate with the colouring matter of cochineal. Barytes and strontites do not occasion any precipitate in a solution of the colouring matter; but they change the hue to violet, like alkalis. The affinity of alumina for the colouring matter is very remarkable. When that earth, newly precipitated, is put into a watery solution of the colouring principle, this is immediately seized by the alumina. The water becomes colourless, and a fine red lake is obtained, if we operate at the temperature of the atmosphere; but if the liquor has been hot, the colour passes to crimson, and the shade becomes more and more violet, according to the elevation of the temperature, and the continuance of the ebullition.

If, before adding alumina to the watery solution of the colouring principle, some drops of an acid be poured into this, the lake obtained is at first of a brilliant red; but the slightest heat changes it to a violet hue. The same effect is produced by putting into the solution of the colouring principle some grains of an aluminous salt. But, on the contrary, if we add to the colouring principle a small quantity of alkali, potash, soda, ammonia, or their subcarbonates, and if we then diffuse through the solution some gelatinous alumina, the liquor rendered violet by the alkalies returns instantly to the red, by the formation of a lake which readily precipitates. In this case, we may keep the mixture boiling for a long time, without making the lake perceptibly violet. This property

cannot, however, be quite restored by alkaline saturation, especially if the action of the alkali has been some time continued. These facts may serve to explain several phenomena which have been observed in the operations of the scarlet or crimson dye.

Most salts exercise on the colouring matter of cochineal an action characterized by changes in the hue; but only a small number are capable of precipitating it, when it is in a state of perfect purity.

Nitrate of silver has no action on it. The soluble neutral salts of lead change the red colouring matter to violet; and the acetate of lead determines immediately an abundant precipitate. This precipitate keeps its tint, though there be an excess of acetic acid. By passing a stream of sulphuretted hydrogen gas through the combination, it is decomposed, and the colouring matter is then obtained in a state of purity. Protonitrate of mercury produces a violet precipitate in the solution of the colouring matter; the deutonitrate precipitates less easily the colouring matter; what falls is of a scarlet hue. Corrosive sublimate has no action on it. The salts of copper cause no precipitate, but change the colour to violet; and the salts of iron give a brownish tint, without producing any precipitate. The salts of tin exercise on the colouring matter of cochineal a remarkable action. The muriatic protoxide of tin forms a very abundant violet precipitate in the liquid. This precipitate verges on crimson, if the salt contains an excess of acid. The muriatic deutoxide of tin produces no precipitate, but changes the colour to scarlet red. If gelatinous alumina be now added, we obtain a fine red precipitate, which does not pass to crimson by boiling.

The salts of lime, barytes, and strontites, perfectly neutral, equally change the colouring principle to violet; but no precipitate can be obtained, except with sulphate of lime.

The aluminous salts, even slightly acidulous, make the colour pass to crimson, especially with the aid of heat; none of them produces any precipitation; they even counteract the precipitation of the colouring matter by alumina, of which, in that case, a great excess is required to deprive of colour a liquor tinged with cochineal. Crimson, or even violet lakes, are then obtained.

The neutral salts of potash, soda, and ammonia, occasion a violet tinge, but no precipitate. The salts, with excess of acid, as the binoxalate and bitartrate of potash, change the colour to scarlet; but still without precipitation.

It appears, therefore, to MM. Pelletier and Caventou, that the metals susceptible of several degrees of oxidizement act like the acids when they are oxidized to a maximum, and like alkalies when they are in the lower stage of oxidizement; and that this alkaline influence of certain oxides may be exerted in the midst of an acid liquid, when these oxides are capable of forming with the colouring principle an insoluble compound, while it is totally destroyed by the excess of acid, if the oxide can produce only soluble combinations, as is the case with soda and potash.

Tannin and astringent vegetable matters form no precipitates with the colouring principle of cochineal. This pure colouring principle was ignited with deutoxide of copper, and yielded a gas composed of ninety-eight parts of carbonic acid and two of hydrogen. No appreciable portion of azote was obtained.

To this colouring principle the name *Carminium* has been given, because it forms the basis of the pigment called *carmine*.

The cochineal, after having undergone the action of ether and alcohol, was treated in the digester with water, till it ceased to give out colour. There then remained a translucid, gelatinous, brownish matter, of which some

portions were white, insoluble in cold water, giving up to boiling water merely a portion of their substance, without any trace of colouring principle. The first watery decoctions were much coloured; the last were colourless. The water acts on cochineal, so as to carry off the last portions of the colouring matter, and the fat substance, and to dissolve a portion of the animal matter, which constitute, as it were, the basis or skeleton of this insect.

This white or brownish translucent animal matter, when exposed to a moderate heat, dries, takes a horny appearance, and can then be kept for a long time; but when, on the contrary, it is left in the moist state, it is spontaneously decomposed with the diffusion of a nauseous smell. At a higher heat, it furnishes all the products of animal matters, and particularly carbonate of ammonia. Boiling water slowly dissolves a little of the animal matter; and it putrefies with great readiness. It differs from gelatin, in not being thrown down from water by alcohol, and in being precipitable in whitish flocks by all the acids.

Chlorine precipitates the animal matter of cochineal, but iodine produces no sensible effect on its solution. Potash and soda communicate to water the power of dissolving this animal matter in abundance. When they are neutralized by acid, the matter is recovered; but if the acid is in excess, it forms an insoluble compound with an animal matter. All the salts with excess of acid precipitate the animal matter, and are brought to the neutral state. Thus the precipitate seems formed of the animal matter and of the acid that is in excess. But several of the neutral salts are decomposed by the animal matter, and precipitates are obtained containing it, the metallic oxide, and the acid. In this way, the salts of lead, copper, and tin, act. The nitrate of silver also possesses this property; and since this salt does not precipitate the colouring matter of cochineal, while it is very

sensible in regard to the animal matter, it forms a good reagent of the purity of carminium.

The fat matter obtained by the evaporation of the ethereous tinctures is of an orange-yellow colour. The first tinctures afforded a fat matter more coloured and reddish, proceeding from a certain quantity of carminium, which the fat matter had taken up. This fat matter has the smell of decoctions of cochineal. By dissolving it in hot absolute alcohol, there was obtained on cooling a large quantity of a pearly crystalline matter, of a rose-white colour, sprinkled with red points. By repeated solutions and crystallizations, it was rendered colourless; nor did it retain either taste or smell. Insoluble in water and cold alcohol, it dissolved in ether, fused at a heat of 40° Cent. (104° Fahr.), and formed with alkalies well characterized soaps. This substance is therefore a fat, translucent, crystallizable, similar to what M. Chevreul has found in the fats of mammiferæ, and which he has called *stearine*. In cochineal, a little *elaïne* is associated with it, which is obtained by evaporating off the alcohol.

The pretended yellow colouring matter of cochineal, of which mention is made in some books, does not exist. Fat matter, loaded with carminium, has been mistaken for it; for carminium affords yellow solutions, when it contains a fat matter in a pretty large proportion. Carminium even possesses the property of rendering the fat matter soluble in water. In fact, if we treat cochineal with boiling alcohol, without having exposed it previously to ether, we obtain a kind of crystals similar to what are mentioned in the beginning of this memoir, but much more loaded with fat matter. These crystals do not readily dissolve in water, and the solution is of an orange-yellow approaching to red. When treated by the methods above pointed out, they are found to be composed of carminium and fat matter in a very large proportion; and

though entirely soluble in water, they retain still a little animal matter.

By incinerating cochineal, certain salts were found in the residue. Hence the general products are as follows:—

1. Carminium. 2. A peculiar animal matter. 3. A fat matter, containing stearine, elaïne, and odorant principle. 4. Salts, phosphate of lime, carbonate of lime, muriate of potash, phosphate of potash, potash united to an organic acid.

SECOND PART.—*Of Cochineal in reference to its employment in the Arts.*

All the acids form precipitates in the watery decoction of cochineal, but these precipitates are stronger in proportion to the abundance of the animal matter; hence they do not appear, or only after a certain time, when the boiling is slight, or the decoction too much diluted. The precipitates are generally of a pretty fine colour; but the shade varies according to the acid employed, and its quantity. The acidulous salts, such as the bitartrate and binoxalate of potash, also produce precipitates in the decoction of cochineal. The alkalies change the colour to crimson without causing any precipitate; they even redissolve the precipitates occasioned by the acids.

If we add to water in which cochineal is to be boiled a certain quantity of alkali, there is then dissolved a much larger quantity of the animal matter; and when we thereafter add some acid, a much more abundant precipitate takes place. These precipitates are commonly of a beautiful red. By drying they take so deep a colour as to appear brown; but on diffusion through water, they recover their brightness. The alkali appears to act in the decoction, not only as a solvent of the animal matter, but likewise by modifying the colouring

matter. These precipitates are perfectly pure carmines. The neutral alkaline salts, and most of the metallic, act on this decoction as on the solution of carmine.

It has been remarked, that the decoction of cochineal can be kept a long time without alteration. It is known that carminium cannot pass into the putrid fermentation, but the animal matter is very easily decomposed. This, however, in the decoction of cochineal, seems to be preserved from change by its union with the colouring matter.

On Carmine and Carminated Lakes.

The process followed in Germany for making carmine, which consists in pouring a certain quantity of solution of alum into a decoction of cochineal, is the most simple of all, and affords an explanation of the formation of carmine, which is merely the *carminium* and the animal matter precipitated by the excess of acid in the salt, which has taken down with it a small quantity of alumina; but it appears that alumina ought not to be regarded as essential to the formation of carmine. In fact, by another process, called by the name of Madame Cenette of Amsterdam, the carmine is thrown down, by pouring into the decoction of cochineal a certain quantity of the binoxalate of potash. When carbonate of soda is added, then carminated lake also falls down. That carmine is a triple compound of animal matter, carminium, and an acid, appears from the circumstance, that liquors which have afforded their carmine, when a somewhat strong acid is poured into them, yield a new formation of carmine by the precipitation of the last portions of the animal matter. But whenever the whole animal matter is thrown down, the decoctions, although still much charged with the colouring principle, can afford no more carmine. Such decoctions may be usefully employed to make car-

minated lakes, saturating the acid with a slight excess of alkali, and adding gelatinous alumina. The precipitates obtained on adding acids to the alkaline decoctions of cochineal, are therefore true carmines, since they do not contain alumina; but the small quantity of alumina which is thrown down by alum in the manufacture of carmine, augments its bulk and weight. It gives besides a greater lustre to the colour, even from diluting and weakening it a little.

The carmines found in the shops of Paris were analyzed, and yielded the same products. They decomposed by the action of heat, with the diffusion at first of a very strong smell of burning animal matter, and then of sulphur. A white powder remained, amounting to about one-tenth of the matter employed, and which was found to be alumina. Other quantities of carmine were treated with a solution of caustic potash, which completely dissolved them, with the exception of a beautiful red powder, not acted on by potash and concentrated acids, and which was recognized to be red sulphuret of mercury or vermilion. This matter, evidently foreign to the carmine, appears to have been added, in order to increase its weight.

The preceding observations and experiments seem calculated to throw some light on the art of dyeing scarlet and crimson. The former is effected by employing a cochineal bath, to which there have been added, in determinate proportions, acidulous tartrate of potash, and muriatic deutoxide of tin. The effect of these two salts is now well known. The former, in consequence of its excess of acid, tends to redden the colour, and to precipitate it along with the animal matter: the latter acts in the same manner, at first by its excess of acid, then by the oxide of tin which falls down also with the carmine and animal matter, and is fixed on the wool, with which it has of itself a strong tendency to combine. MM.

Pelletier and Caventou remark, that "to obtain a beautiful shade, the muriate of tin ought to be entirely at the maximum of oxidizement; and it is in reality in this state that it must exist in the solution of tin prepared according to the proportions prescribed in M. Berthollet's treatise on dyeing."

We hence see, why, in dyeing scarlet, the employment of alum is carefully avoided, as this salt tends to convert the shade to a crimson. The presence of an alkali would seem less to be feared. The alkali would occasion, no doubt, a crimson-coloured bath; but it would be easy in this case to restore the colour, by using a larger quantity of tartar. We should, therefore, procure the advantage of having a bath better charged with colouring matter and animal substance. It is for experience on the large scale to determine this point. As to the earthy salts, they must be carefully avoided: and if the waters be selenitish, it would be a reason for adding a little alkali.

To obtain crimson, it is sufficient, as we know, to add alum to the cochineal bath, or to boil the scarlet cloth in alum water. It is also proper to diminish the dose of the salt of tin, since it is found to counteract the action of the alum.

The alkalies ought to be rejected as a means of changing scarlet to crimson. In fact, crimsons prepared by this process cannot be permanent colours, as they pass into reds by the action of acids.

Note HH. p. 154.

According to M. Von Grotthuss, carmine may be deprived of its golden shade by ammonia, and subsequent treatment with acetic acid and alcohol. Since this fact

was made known, M. Herschell, colour-maker at Halle, has prepared a most beautiful carmine.

Note II. p. 176.

Chemical examination of Kermes (coccus illicis) by J. L. Lassaigne.

On applying to these insects the processes employed by MM. Pelletier and Caventou in the analysis of cochineal, M. Lassaigne obtained analogous results.

Kermes, treated with boiling sulphuric ether, yielded a yellow fat matter, which may be obtained in an insulated state by evaporation of the solvent; and a little of its red colouring matter may be carried off by digesting it in cold alcohol of 30° Baumé. This fat substance is inodorous, of a slightly styptic taste, without action on litmus infusion, fusible at 45° Cent. (113° Fahr.), and easily saponified by alkalies.

Kermes, exhausted by ether, yields to alcohol, by means of heat, a colouring matter and a brown animal matter. On cooling, the latter is precipitated in reddish flocks, mingled with the colouring matter carried off by the alcohol. The alcoholic solutions, when evaporated in a glass retort, leave the colouring matter of kermes; but to procure it perfectly pure, it must be several times redissolved in alcohol.

This matter has a very deep purple red colour. It has a granular aspect, and crystalline fracture. The air has no action on it. Its powder possesses a beautiful vermilion hue.

Sulphuric ether does not effect its solution; but water and alcohol dissolve it in any proportion. The more concentrated the latter is, however, the less is its

solvent faculty. Reagents affect this matter like carminium, to which it bears a close resemblance.

Kermes, after having been treated successively by ether and alcohol, remains a little coloured. On boiling it with water, the last portions of colouring matter may be removed, and there remains a brownish animal matter, in semitransparent scales, very slightly soluble in water, and possessing all the properties of the animal matter of the cochineal.

It hence appears, that kermes has a chemical composition, very analogous to that of cochineal.—*Annales de Chimie et Physique*, xii. 102.

Note KK. p. 181.

Seed-lac is obtained in the following manner. When the lac has been separated from the stems (sticks) to which it naturally adheres, and is reduced to a coarse powder, the silk and cotton dyers extract its colours as much as they can by means of water; and to the hard and yellowish resinous powder which remains, and which resembles in some measure mustard-seed, the name of *seed-lac* is given.

Shell-lac is procured by melting seed-lac in a cotton bag, above a glowing charcoal fire: when the lac is melted, it is forced through the bag by twisting it, and is received on the smooth trunk of a tree. The resin being the most fusible portion of the lac, passes through the bag in a state of great purity.

The lac-lake contains, besides the colouring matter of the lac, about a third of its weight of resin, a sixth of alumina, and much earthy matter.

Mr Bancroft has given a full account of the mode of preparing *lac-lake*. *Lac-lake* is prepared in India, from stick-lac reduced to powder, by repeated affusions of

boiling water containing a large quantity of soda; but this addition of soda, although it disposes the water to extract the colouring portion of the lac much more copiously, occasions a considerable solution of resin, which is afterwards precipitated, intimately combined with the colouring principle, by the alum employed in its precipitation. Hence the lac-lake, besides its colouring matter, contains, as previously stated, different proportions of resin and alumina. The proportion of resin may be estimated at one-third of its weight, and that of alumina at one-sixth. It contains, likewise, a portion of vegetable matter derived from the mucilaginous bark of an Indian tree called *lodu*, which is supposed to be useful in several respects. But this point has not been hitherto decided. Considerable but variable proportions of sand, and other earthy matters, are usually added to the *lac-lake* by the manufacturers, to increase its weight.

The *lac-lake*, after being ground to a fine powder in proper mills, is put into wooden troughs with water, where it settles, and the colourless supernatant liquor is drawn off. The sediment or moistened powder must then be put into a leaden cistern, where it is diffused through dilute sulphuric acid, whereby a limpid solution of the colouring matter is obtained. Thus it is separated from the foreign substances, resinous or earthy, and rendered capable of application to stuffs. Sulphuric acid possesses the property of destroying the bad effects of the resin, much better than the muriatic.

For dissolving the colouring matter in this way, three pounds of oil of vitriol, specific gravity 1.845, are required for every four pounds of the dry lac-lake before it was milled. The ground and moist lac-lake should not contain more than twice its weight of water. The sulphuric acid is in that case added, and perfectly mixed with the moist powder, stirring up and agitating with a strong rod or ladle of glass or lead. But if the *lac-lake* has

been ground without being moistened, it will be proper, before adding the acid, to dilute this with twice its weight of water. When the preceding mixture is made, it must be left in repose for twenty-four hours in summer, and forty-eight in winter. Then a gallon of boiling water must be added for every pound of *lac-lake* (weighed dry), and the whole must be well mixed. After leaving the mixture at rest for twenty-four hours, the limpid coloured solution ought to be drawn off into another leaden vessel, and the same quantity of boiling water poured upon the residuum. This mixture, after being well stirred, is to be left at rest for twelve hours as before, and then the clear liquor may be drawn off. The same quantity of boiling water may be again thrown on the residuum, which after repose is to be separated. This treatment is to be repeated as long as boiling water acquires colour. When this ceases, a little of the residuum is to be mixed with one-half its weight of carbonate of soda dissolved in a little water, and if the whole colouring matter has not been extracted, it will become *red*, and will deepen in colour. If after this trial there should seem to remain a quantity of colour worthy the trouble of extraction, the residuum should be mixed with from one-sixth to one-fourth of the quantity of sulphuric acid primitively employed, and after leaving the mixture at rest for twelve hours, boiling water is to be poured on it, as above directed. This operation may be resumed till the whole of the colouring matter has been extracted.

The coloured liquid being now all collected in the same vessel, there must be very exactly mixed into it two pounds of pure lime, well calcined and reduced to a fine powder, for every five pounds of sulphuric acid contained in the liquor. This quantity of lime will be sufficient to neutralize four-fifths of the acid, and to carry it down (in the form of sulphate of lime) *without any colouring matter*. The supernatant liquid is then to be decanted, and

the remaining fifth of acid which it contains, disposes the colouring matter contained in the liquor better to penetrate and impregnate the stuff. This liquor or solution of lac colour may be called No. 1. This may be employed without any difficulty in dyeing, as if it were a weak decoction of cochineal, along with the mordants and other acids to be presently described. We shall merely observe at present, that two-thirds of the sulphuric acid prescribed for the *lac-lake* will be sufficient for extracting the colour of the *lac dye;* but although neither the labour nor the expense of extracting the colouring matter of either of these substances be considerable, it is probable that the greater number of dyers will deem it sufficient to subject the *lac-lake*, or the *lac dye*, to the action of sulphuric acid, so as to deprive the resinous portions of *their adhesive property:* in this case, the colouring matter becomes soluble in the dyeing liquor, and may be applied to the stuff, without any previous separation of the resinous and other matters insoluble in these preparations.

For this purpose, one pound of sulphuric acid at most, should be employed for every two pounds of *lac-lake* weighed in its dry condition; two-thirds of a pound will be sufficient for two pounds of the *lac dye*. Each of these substances being moistened and milled, as we have already explained, ought to be mixed in a leaden vessel with the determinate proportion of sulphuric acid. After having stirred them well at different times, the mixture must be left at rest for at least twenty-four hours in summer, and thrice this time in winter. After this, it will be proper to employ it immediately in the manner to be presently pointed out. The cost of the preparation may be estimated at 20 per cent, independent of the expense of grinding. This preparation of lac-lake or the lac dye, may be called No. 2.

From two to three pounds of *lac-lake*, according to the quality, and perhaps a little less of the *lac dye*, can produce the effect of a pound of cochineal; but to give the greatest vivacity to the colour, a sixth or an eighth of nitromuriate or other solution of tin, must be used in the dyeing more than is employed with cochineal, because the alumina, by which the colour of the lac was at first precipitated, and of which a portion has been redissolved and retained by the sulphuric acid, and in the operation just described, would give to the colour a crimson tint, unless the oxide of tin be employed in such quantity as to repel, by its superior attraction (affinity), the alumina, and prevent it from becoming attached to the stuff and to the colouring matter.

It is admitted, that the colour extracted from lac resists the action of acids much better than cochineal. Besides this advantage, the scarlet colour may be obtained better and cheaper with this substance at a single operation. For this purpose, we must put into a vessel of block tin a sufficient quantity of clear soft water, to which we add one pound of tartar, or, which is better, powdered cream of tartar, for every ten pounds of stuff, with as much either of quercitron bark in powder, contained in a bag, or otherwise fustet (*rhus cotinus*) in chips, also enclosed in a bag. These ingredients will produce abundance of the yellow colour. Having raised this composition to the boiling point, we must add nitromuriate of tin, or any other solution of this metal, with a suitable quantity of the colour of *lac-lake* No. 1. or of that of No. 2. This mixture being thoroughly made, the stuff, previously cleaned and moistened, is to be thrown into the bath, and turned through it by a winch, as is usually practised, till it has acquired sufficient body and brilliancy of colour. This commonly takes place in an hour, if the liquor be kept constantly boiling. To prevent any chance of imperfection in the dye, a little more

lac colour should be used for each operation, since the superfluity will serve, without any loss, for the other pieces of stuff which are to be dyed in the sequel.

If it be judged proper to neutralize a portion of the sulphuric acid employed in preparing No. 2. to prevent the harshness which the acids are supposed to give to goods, this may be done by the addition from time to time of carbonate of soda, not exceeding a pound, or a pound and a half, for every pound of sulphuric acid that was employed.

If one-fourth part of the solution No. 1. or of the preparation No. 2. be kept out, and there be added, *towards the end of the process*, a quarter of an ounce of cochineal for every pound of stuff to be dyed, we shall obtain a colour equal in vivacity and beauty to scarlet dyed entirely with cochineal.

When a stuff is dyed with the *lac-lake* on purpose to change its shade afterwards to a bright rose, to a crimson or purple, neither quercitron nor fustet should be used, nor more than half the quantity of tartar. The stuff dyed without these ingredients is to be thereafter washed, and put into a clean vessel, along with warm water, containing a moderate portion of carbonate of soda in solution, or ammonia. If a more decided purple be wanted, we must add a little archil to the bath, or alkaline liquor, and then proceed as usual. But as the colour of archil is not sufficiently permanent, dyes partaking more or less of the purple, moderately beautiful and fast, may be obtained directly, by adding to the bath composed of No. 1. or No. 2. a suitable proportion of a decoction of logwood. This addition need not, however, be made before the end of the operation; and when logwood is to be used, neither fustet nor quercitron are needed; but as tartar renders the colour of logwood more durable, it becomes necessary, and the solution of tin is indispensable. We must, however, beware of turning the stuff with the winch

in the bath, before the logwood be added, and thoroughly mixed with the liquor.

If a stuff be dyed with one of the preparations No. 1. or No. 2.; if pulverized quicklime in sufficient quantity to neutralize the acid be added to the bath; and if the boiling be kept up for a quarter of an hour, a good crimson may be obtained without any solution of tin, or other ingredients, that are required for scarlet. In this case, the alumina redissolved by the sulphuric acid, and the sulphate of lime, serve for mordants.

Mr Hatchett, in his admirable memoir on lac, published in the Philosophical Transactions for 1804, states the composition of stick-lac to be,

Colouring extract, - -	20
Resin, - - -	136
Vegetable gluten, - -	11
Wax, with a little colouring extract,	12
Extraneous substances, - -	13
	192
Loss,	8
	200

200 grains of seed-lac yielded him only		5 of colouring matter.
500 shell-lac,	2.5	
	454.5 resin.	

Mr Hatchett in that memoir states, that the colouring extract of lac is insoluble in ether, scarcely soluble in alcohol, and slightly so in water, but readily in sulphuric acid, forming a deep brownish-red solution, which being diluted with water, and saturated with potash, soda, or ammonia, becomes changed to a deep reddish purple. Strong acetic acid dissolves it with great ease, and forms

a deep brownish-red solution. The lixivia of potash, soda, and ammonia, act powerfully on this substance, and almost immediately form perfect solutions, of a beautiful deep purple colour. Pure alumina put into the aqueous solution does not immediately produce any effect; but upon the addition of a few drops of muriatic acid, the colouring matter speedily combines with the alumina, and a beautiful lake is formed. Mr Bancroft states, that muriatic acid does not answer so well as sulphuric, in preparing the lac dye.

Muriate of tin, says Mr Hatchett, produces a fine crimson precipitate, when added to the aqueous solution. A similar coloured precipitate is also formed by the addition of solution of isinglass. Probably the tannin thus indicated was afforded by the small portions of vegetable bodies, from which the stick-lac can seldom be completely separated.

Twenty grains of borax, dissolved in four ounces of water, form a liquid capable of dissolving 100 grains of shell-lac. This solution of lac in water, mixed with various colours, as vermilion, fine lake, indigo, prussian blue, sap-green, or gamboge, forms an excellent vehicle for their application to paper, since, when it dries, the colour cannot be removed with a moistened sponge. The Indians make an ink by mixing the above vehicle with lamp-black.

Note LL. p. 204.

M. P. A. de Bonsdorff has pointed out several new applications of brazil wood as a chemical reagent. It may enable us to distinguish one acid from another. Sulphuric acid concentrated, or diluted with three parts of water, instantly gives to paper stained with brazil wood a bright rose colour, which, attracting humidity

from the air, gradually passes to orange. More dilute, it gives a dirty yellow. Nitric and muriatic acids act like the sulphuric. Sulphurous acid gas blanches the colour. Concentrated hydriodic acid yields a rose colour, which becomes first yellow on the edges, and finally throughout. Diluted acid gives a fading yellow. Fluoric acid, or fluosilicic, causes a clear red colour. Diluted, it instantly produces a fine lemon-yellow colour, which in the space of a minute disappears, and soon leaves a tint of greenish-grey, which, observed by transmitted light, is of an olive-green. When exposed to the gaseous acid, the paper passes through these transitions of colour, a phenomenon which does not occur with the other acid vapours. Fluoboric acid has the same habitudes. Boracic acid does not act at first, but by and bye the colour of the paper becomes pale, and ends in a white, bordering a very little on red. If boracic contain traces of the sulphuric, a marked yellowish colour is formed, which soon disappears. Concentrated phosphoric acid gives a rose colour, which, in the air, slowly changes to orange. Dilute, it yields a permanent yellow. Hypophosphorous gives a red, which passes through yellow to white. Concentrated arsenic acid produces a pretty durable rose colour; diluted, a fugitive yellow. Arsenious acid has no sensible effect. Concentrated acetic acid gives instantly a sombre yellowish colour, which immediately disappears, and is succeeded by a pale violet colour, which, viewed by transmitted light, is a very deep violet-red; diluted, a yellowish colour, becoming violet-red. When this acid is mixed with the sulphuric, a yellowish colour appears, instead of violet-red. Acetic acid, containing no more than $\frac{1}{200}$ part of sulphuric, affords a very perceptible yellowish colour. Citric acid, a beautiful permanent yellow. Tartaric and malic acids, a yellow becoming dirty. Concentrated oxalic acid, an orange

colour becoming slowly yellow; diluted, a durable yellow.

Woollen cloth, plunged into a boiling bath of brazil wood, then drained, and dipped for some minutes in a dilute phosphoric or citric acid, or what is cheaper and equally good, in a dilute bisulphate of lime, takes a very lively yellow dye, which resists washing with soap. Silk may be dyed by the same process, but cotton or linen cannot.

The bright fugitive red, called fancy-red, is given to cotton by Nicaragua, or peach wood, a cheap kind of brazil wood.

The cotton being scoured and bleached, is boiled with sumach. It is then impregnated with a solution of tin (at 5° Baumé, according to Vitalis). It should now be washed slightly in a weak bath of the dyeing wood, and lastly worked in a somewhat stale infusion of the peach or brazil wood. When the temperature of this is lukewarm, the dye is said to take better. Sometimes two successive immersions in the bath are given. It is now wrung out, aired, washed in water, and dried.

M. Vitalis says, that his solution of tin is prepared with two ounces of tin, and a pound of aqua regia made with two parts of nitric acid at 24° Baumé, and three parts of muriatic acid at 22°.

For a *rose* colour, the cotton is alumed as usual, and washed from the alum. It then gets the tin mordant, and is again washed. It is now turned through the dye-bath—an operation which is repeated if necessary.

For *purple*, a little alum is added to the brazil bath.

For *amaranth*, the cotton is strongly galled, dried, and washed. 2. It is passed through the black cask *(tonne au noir)* till it has taken a strong grey shade. 3. It receives a bath of lime water. 4. Mordant of tin. 5. Dyeing in the brazil wood bath. 6. The two last operations are repeated.

The following example of a spirit red, directly applied in calico printing, is given in Rees' Cyclopædia, article COLOUR:—

Prepare an aqua regia, by dissolving two ounces of sal ammoniac in one pound of nitrous acid, sp. gravity 1.25. To this add two ounces of fine grain tin; decant it carefully off the sediment, and dilute it with one-fourth its weight of pure or distilled water.

To one gallon of water add one pound of cochineal, ground as fine as flour; boil half an hour; then add two ounces of finely pulverized gum dragon *(tragacanth)*, and two ounces of cream of tartar; and stir the whole till it is dissolved. When the liquor is cool, add one measure of the preceding solution of tin to two of the cochineal liquor, and incorporate well by stirring. Apply this with the pencil or block; suffer it to remain on the cloth six or eight hours; then rinse off in spring water. This colour will be a bright and beautiful scarlet.

2. Boil twelve pounds of brazil chips during an hour, in as much water as will cover them. Draw off the decoction, pour on fresh water, and boil as before. Add the two liquors together, and evaporate slowly down to one gallon. To the decoction, while warm, add four ounces of sal ammoniac, and as much gum dragon, or senegal, as will thicken it for the work required. When cool, add one of the solution of tin above described to four, six, or eight of the brazil liquor, according to the colour wanted. Suffer it to remain for 18 or 20 hours on the cloth; then rinse off in spring water as before. The colour will be a pale and delicate pink. If it be required deeper, the decoction must be made stronger, and used in the proportion of three or four to one of the solution of tin. Nicaragua or peach wood, though not so rich in colouring matter as brazil, yields a colour, however, which is, if possible, more delicate and beautiful.

Note MM. p. 213.

Dr Dingler, manufacturing chemist at Augsburg, gives the following prescription for dyeing with brazil woods of inferior qualities, and clearing these dyes of their tawny pigment. The watery infusions of these poorer dyewoods are to be evaporated till from four parts of wood by weight there remain only 12 or 15 of liquid. When this liquid has cooled, we must pour into it, after 12 or 18 hours, two parts of skimmed milk. After stirring this mixture well, we boil it for a few minutes; then pass it through a piece of thick flannel. The tawny colour will be then seen to attach itself to the caseous part of the milk, which spontaneously precipitates from this decoction, without occasioning the least loss in the quantity of red colour. The remaining red is of a pure tint. Perhaps this process might be useful with madders, which are supposed to consist of the same two colours. Two pounds of milk are sufficient for six or eight pounds of young woods.

Note NN. p. 218.

The colouring principle of logwood was discovered by M. Chevreul, and called *Hematin.*

Ground logwood is to be digested in water at a temperature of from 120° to 130° Fahr. After a few hours the liquor is filtered and evaporated to dryness. The residuum is put into alcohol of 36° Baumé for a day. After this he filters the new liquor, concentrates it till it thickens, pours into it a little water, exposes it anew to a gentle evaporation, and then leaves it to itself. By this means he obtains a pretty large quantity of crystals

of *hematin*, which, to be rendered pure, need only be washed in alcohol and dried.

This substance is crystalline, of a rosy-white, very brilliant when viewed through a lens, having a taste slightly astringent, bitter, and acrid.

Exposed to the action of fire in a retort, hematin affords all the products of animal substances, and, besides, a small quantity of ammonia, which proves that it contains azote.

Boiling water dissolves it easily, taking an orange-red colour, which passes to yellow by cooling, but which may be restored by heating the solution anew. When this is evaporated, crystals of hematin are formed. On adding to it some acid very gradually, it changes to yellow and then to red. Sulphurous acid yellows and then blanches the colour.

Potash and ammonia cause the solution of hematin to take a purple red; if a great excess of these alkalies be added, the colour becomes violet-blue, then brown-red, and finally yellow-brown. The hematin is now decomposed; it cannot be recovered by acids.

If a current of sulphuretted hydrogen gas be passed through water charged with hematin, it takes a yellow colour, which vanishes after a few days. The sulphuretted hydrogen appears to act by combining with the hematin, and not by deoxidizing it. This is easily verified by putting into a small jar, filled with mercury, a certain quantity of the blanched solution, and then introducing a bit of pure potash. This melts, combines with the sulphuretted hydrogen, and the colour of the hematin immediately reappears.

Protóxide of lead, protoxide of tin, hydrate of tritoxide of iron, hydrate of copper, hydrate of nickel, oxide of zinc and its hydrate, flowers of antimony, oxide of bismuth, combine with hematin, and give it a blue

colour, with a loss of the violet shade. The deutoxide of tin acts on it in the manner of the mineral acids.

Hematin precipitates glue from its solution, under the form of reddish flocks.

M. Chevreul proposes it as a good reagent for acids. —*Annales de Chimie*, lxxxi. p. 128.

Note OO. p. 241.

Dr John, of Berlin, gives the following as the results of his examination of annotto. The grains of Rocou contain an aroma, an acid, resin combined with the colouring matter, vegetable mucilage, fibrin, coloured extractive, and a peculiar matter which approaches to mucilage and extractive. This analysis explains the reason why an alkali is added to annotto when it is employed in dyeing. The alkali combines with the resin, and forms a soap which dissolves in water. The alkali acts likewise on the colouring matter, and renders it more lively.

Note OO. p. 251.

The application to stuffs of colours derived from the mineral kingdom, is one of the most marked improvements in modern dyeing. Mr Raymond received from the French government, in 1811, 8000 francs, as a reward for communicating to the public his process for dyeing silk of a uniform, fast, and bright prussian blue colour.

By a gentle calcination till sulphurous acid fumes begin to appear, he first converts copperas into the red sulphate of iron. This he dissolves in sixteen times its

weight of warm water, and filters, when he has a clear solution of a lively yellow colour, bordering on red. The silk, prepared as for the indigo dye, is to be put into the solution of iron, and left there a shorter or longer time, according to the shade of blue that is wanted. It is then taken out of the vat, and wrung very dry over a pole placed above the vat. The silk is next carried to the stream, to be thoroughly cleansed, which is effected by twice beetling it, and plunging and agitating it each time in the running water. The water now wrung out of the silk should not be able to affect solution of ferroprussiate of potash. An ounce of green copperas will furnish red sulphate sufficient for a pound of water. Dissolve in pure water, heated to 60° Reaumur (167° Fahr.), and put into a deal vat, or tub, one ounce of ferroprussiate of potash for every twelve ounces of silk to be dyed. When the prussiate is entirely dissolved, add one part, or even rather more, of muriatic acid, at about 21° Baumé, stirring the mixture well. When the liquor has acquired a greenish colour, the silk must be immediately plunged in it, and stirred about for some minutes, after it has been well wrung and disposed upon poles, in the same manner as for the iron mordant.

The silk having received in an equal manner the dye of prussian blue, it is taken out of the prussiate vat, and after being well wrung on a pole above the vat, it is taken to the river, where it must receive two or three beetlings, and must be plunged and agitated each time in the water, (in the same manner as for dyeing black), in order to free it entirely from any portion of prussiate of iron that is not truly combined in it, and which, by remaining partly interposed in the silk, would cause it to dye the water blue, and also to produce stains of blue on any white body on which it is rubbed. 50° Reaumur (144° Fahr.) is the most suitable temperature for the prussiate bath. Should the bath of prussiate of potash

become of a blue colour, when the silk is dipped into it, it is an indication that it contains either too much prussiate or muriatic acid, or that the silk, after passing through the mordant of oxide of iron, had not been sufficiently cleaned in the river.

Lastly, the silk being well washed in the stream, and thoroughly wrung with the hands, is to be placed loosely on the poles, as in the preceding operations; after which it must be well stirred and agitated in a large vessel, three-fourths filled with cold water, and to which must be added, for a hundred pounds of silk, two pounds of ammonia (water of), marking 21° of Baumé's spirit hydrometer. The blue colour will immediately become at least three shades deeper, taking a much richer and brighter tint, at the same time fixing more perfectly in the silk. This change is effected in a few minutes. The silk must then be wrung by hand, and rinsed in running water without beating. After this it is dried on the poles, in the same manner as other dyed silks. It need be left on the poles only twenty hours, to give the colour time to come out well; for it is observed, that this colour, far from fading in the drying, as is the case with many other colours, is improved, and acquires a greater richness of tint. The solution of a little soap added cold to the ammonia bath improves it, giving also softness to the silk, and rendering it more easy to separate. The soap must be uniformly dissolved.

Woollen cloth takes the above dye, but it must be left longer than silk in the iron mordant.

In 1819, M. Braconnot of Nancy applied sulphuret of arsenic (orpiment) to stuffs, so as to give them a yellow dye. He mixed one part of sulphur, two parts of arsenious acid, and five parts of potash of commerce. This mixture is fused in a crucible, at a heat approaching to redness. The resulting yellow mass is to be dissolved in hot water; and the liquor is filtered to separate it from a

sediment formed in a great measure of metallic arsenic in brilliant scales, and of a small quantity of a flocky chocolate-coloured matter, apparently a subsulphuret of arsenic. Into the filtered liquor, diluted with water, weak sulphuric acid is to be poured, which causes a flocky precipitate of a superb yellow colour. This precipitate, washed in a cloth, dissolves with extreme readiness in water of ammonia, constituting a yellowish liquid, into which an excess of ammonia is poured to deprive it entirely of colour. In this liquor, the wool, silk, cotton, or linen to be dyed, is plunged; and it may be diluted to any degree, corresponding to the depth of shade wanted. The washed sulphuret of arsenic should be dissolved in ammonia, only when it is wanted; and metallic vessels or utensils should be carefully avoided. When the stuffs are taken out of this bath, they are colourless; but they imperceptibly assume a yellow colour on the dissipation of the ammonia. They are, therefore, freely exposed to the air, so that it may play over their surfaces; and as soon as the colour has taken its utmost intensity of shade, they may be washed and dried.

Wool should be tramped in the ammoniacal bath, till it be uniformly impregnated with it; it is then to be squeezed or wrung out very slightly and uniformly, or it may be even allowed simply to drain. Silk, cotton, hemp, linen, require merely to be dipped in the dyeing liquor. They are very easily impregnated, and must be well wrung out. This colour is affected only by alkalies. It may be had of every shade, from golden yellows to the palest.—*Annales de Chim. et de Phys.* xii. 398.

M. J. L. Lassaigne in 1820 published in the *Annales de Chimie et de Physique*, a process for fixing chromate of lead on cloths, which has since become pretty common in this country. After immersing for a quarter of an hour, at the ordinary temperature, hanks of scoured silk in a weak solution of acetate of lead, he took them out and

washed them with a great deal of water. Thus prepared, they were dipped into a weak solution of chromate of potash. They immediately took a fine yellow colour, and at the end of ten minutes the effect was completed. From this colour being decomposed in part by soap water, M. Lassaigne conceives that it will be chiefly applicable to silks. But by applying a mordant of acetate or nitrate of lead, and passing the goods through bichromate of potash, a very beautiful and sufficiently fast yellow is now given to cotton goods in this country. The bichromate acts instantly on the mordant, and does not require that duration of immersion which M. Lassaigne found to be necessary with the neutral chromate.

The application of the chromate of lead on Turkey red cloth, forms a brilliant style of calico printing, now carried to high perfection at the establishment of Messrs Monteith at Glasgow. Nitrate of lead is dissolved in liquid tartaric acid, of a specific gravity about 1.250: this solution is thickened with gum, and applied with the block to cloth previously dyed Turkey red. Whenever the paste is dried, the cloth is slowly passed through an aqueous solution, nearly saturated, of chloride of lime, kept at the temperature of about 100° in a stone trough. The tartaric acid disengaging the chlorine, discharges the colour of the Turkey red at the points of application, while the nitrate of lead, or rather perhaps the oxide of lead, remains attached to the cloth. This is immediately washed, and then passed through a solution of bichromate of potash, by means of the padding machine.

An orange colour was a few years ago given to goods in calico printing, by means of the crystals of hydrosulphuret of soda and antimony, which are hence called orange crystals. But the use of the alkaline solution of sulphuret of antimony had been long known and practised by the Lancashire printers. It was invented by John Mercer, a colour maker with Messrs Fort. The salt is

formed by boiling finely ground sulphuret of antimony in caustic soda ley, and crystallizing.

The thickened solution of the hydrosulphuret is applied to the cloth, and it is either washed off in weak sulphuric acid, or in water, after being left some days on the cloth. This dye is bright and pleasing, but very fugitive, and has hence gone into disuse.

For the following observations on calico printing, I am indebted to a much esteemed friend, who unites scientific knowledge to practical skill.

Bleaching.—To bleach cloth for printing, it is first of all to be singed, and then steeped in warm water (sometimes with an addition of spent ley) for a day or two. It is then well washed and boiled in potash ley, five different times.

For 2000 lbs. (original weight) of cloth, 1000 gallons of water, and forty to forty-five lbs. of potash are employed each time. The boiling is continued eight or ten hours.

Betwixt each operation the cloth must be well washed, and after the third and fourth boil it must be spread upon the grass, or steeped for a night in a weak solution of chloride of lime. After this, it is winced a few minutes in a warm dilute sulphuric acid, well washed, and dried.

The principal processes, or rather *styles of work*, as they are called, are the following:

1. Single coloured plates.
2. Ditto ditto grounded.
3. Light or dark chintzes.
4. Dark grounds, with a white discharge.
5. Blue grounds, with a white resist.
6. Blue grounds, with a red and white resist together.
7. Chemical, or spirit colours.

1. *Single Colours.*—Called plates, from their being generally printed with the copperplate. This process consists generally in printing a mordant upon the cloth;

which mordant attracts a colouring matter when the cloth is dyed. The mordant is different, according to the colour that is wanted.

For *black*. An acetate of iron is used of the sp. gr. 1.040.

For *purple*. An acetate of iron, sp. gr. 1.12, with six, eight, or twelve times its volume of water, according to the shade of colour required, and the mass to be printed.

For *red*. A solution of three pounds alum in a gallon of water, one-half of which is decomposed by acetate of lime or lead.

For *chocolate*. Mixtures of acetate of iron, sp. gr. 1.12, with red mordant, in the proportions of one to two, four, six, according to the shade.

Each of these mordants is thickened with flour, or, in some cases, with gum, and printed upon the bleached cloth.

After being exposed to the air for a few days in a warm room, the goods are taken down and passed through the dung copper at a heat of from 150° to that of boiling water. They are then washed, and winced in another clean dung copper, at a lower degree of heat than before, and then washed again. They are now ready to be dyed.

All the colours last mentioned, viz. black, purple, red, and chocolate, are dyed with madder and sumach, except purple, in which the sumach is omitted. Different quantities of madder are used, according to the quantity of colour on the cloth, from one pound per piece of 21 square yards, to three and even three and a half pounds; the sumach about one-eighth of the madder. The goods are *entered* when the copper is cool, and the heat is brought up gradually during two or three hours, and sometimes the ebullition is kept up for a quarter of an hour; the pieces all the while being turned over a wince,

from the one side of the copper vessel to the other. They are then washed, and boiled in bran and water ten or fifteen minutes.

If they have much white, they must be *branned* a second and a third time, washing between each operation.

To complete the whitening, they are spread upon the grass for a few days; or what is more expeditious, and more generally practised now, they are winced a short time in a warm but weak solution of chloride of lime.

For *indigo blue.* A strong solution of caustic potash is made, in every gallon of which, by the aid of as much orpiment, twelve or sixteen ounces of good indigo is dissolved. The solution, when clear, is thickened with gum. This being printed upon the cloth, nothing more is necessary than to wash it when dry.

For *prussian blue.* The same mordant is used as for black; but after cleansing, the piece is winced in a solution of prussiate of potash, in which the prussic acid has been set free by means of sulphuric acid.

For *gold.* Five pounds sulphate of iron and one and a half pounds acetate of lead are dissolved in a gallon of water: the solution, thickened with gum, is printed on the cloth; and, after eight or ten days' age, is winced in a solution of potash made thick with lime. As soon as the black oxide of iron, which is precipitated, commences to redden, the piece is removed to a vessel of water, and then washed.

2. *Single colours grounded.*—A second, and sometimes third colour, is grounded or printed in with a small block, generally after the first has been dyed.

Bark yellow. A mordant is used, the same as for red. The piece, when slightly dunged, is dyed about an hour with one pound of quercitron bark, the infusion being gradually heated during that time to 130° or 160°.

Berry yellow. A decoction of French, or Turkey, or Persian berries, with half a pound of alum per gallon, is

thickened with flour or gum; and the piece, when dry, is passed through a weak alkaline carbonate, or lime water.

Verdigris green. A solution of sulphate and acetate of copper is put on cloth, which is then passed through a strong solution of potash, in which some protoxide of arsenic has been dissolved.

Drab. The same mordant as is used for purple. Bark, the dye stuff.

Olive. The chocolate mordant dyed in bark. Both these very much diluted, and thickened with gum.

Buff. A weak acetate of iron is applied, and washed in water.

3. *Chintzes.*—A number of different colours printed upon cloth together, viz. black, red, one or two pale reds, purple, blue, green, and yellow. The black, red, and blue, are the same as in No. 1.; the purple, as No. 1., thickened with gum; the two pale reds are weaker solutions of alum and acetate of alumina, thickened with gum; the yellow is berry yellow, applied after the other colours are finished; the green is formed by the yellow falling upon the blue; and all the varieties of orange, olive, &c. by its falling upon the pale reds and purple. The dyeing and subsequent bleaching, are the same as has been described in No. 1., with madder only.

4. *A dark ground discharged.*—When the discharge is printed before the mordant, it consists of concentrated lime juice alone, thickened with gum. The mordant, which is also thickened, is blotched over the whole piece, and dried off it as quickly as possible.

When the mordant is applied first it is not thickened, and the acid has an addition of one pound bisulphate of potash in each gallon. They are dunged and dyed like other single colours. Blacks, instead of madder, are generally dyed with logwood and galls.

5. *Blue grounds.*—To make *a blue paste* for dark blues, three to four pounds sulph. of copper are dissolved in a gallon of water, with a pound or a pound and a half of acetate of lead. The clear solution is thickened with pipe-clay and gum. The pieces printed with this paste are hooked upon a frame, and dipped in a weak blue vat five or six times; then taken out and kept in the air till they become blue. Alternate immersions and airings are thus continued till the requisite shade has been obtained. The goods are then washed and dipped in a weak sulphuric acid, to dissolve the oxide of copper. The blue vat, as is well known, is made by one part of indigo, with two parts sulphate of iron, and about two and a half parts hydrate of lime.

6. A mordant for red, to resist the blue vat, is made by dissolving about four ounces acetate of copper in a red mordant, made from four pounds of alum, and two and a half pounds acetate of lead, per gallon, and thickening the solution with pipe-clay and gum. When this is printed upon the cloth and dipped in the blue vat, it resists the blue, and a white is left, which, when dunged and dyed in madder, becomes red.

A white called *neutral*, is made by dissolving sulphate of copper in concentrated lime juice, and is used along with this red. It must possess the three following properties: 1. Resisting the blue; 2. Remaining white after dyeing, when the red happens to go over it; 3. To leave no oxide of copper upon the cloth.

A berry yellow is grounded in after the blue, white, and red, in this style, are finished.

7. *Chemical colours.*—This name has been given to those colours which are applied topically; most of them are fugitive.

Black. A decoction of logwood and galls, thickened with flour, and, when cold, nitrate of iron mixed with it.

Red. A decoction of brazil or peach wood, with the protomuriate or permuriate of tin.

Purple. A decoction of logwood with muriate of tin.

Blue. Ground prussian blue is soaked in muriatic acid for a day or two, and then as much of it mixed with gum tragacanth water, as is sufficient to give it the desired shade.

Yellow. A decoction of fustic with muriate of tin.

Green. A mixture of the blue and yellow.

All these colours are simply washed off in water.

M. Vitalis gives the following prescriptions in calico printing:—

Mordant for Reds.

240 litres of boiling water;
150 pounds of pure alum;
50 pounds of acetate of lead;
6 pounds of commercial potash or soda;
6 pounds of chalk;
3 pounds of ground brazil wood.

Into a vat capable of holding 400 litres, and partly filled with the 240 litres of boiling water, the alum in powder is put, and then the decoction of brazil wood. After stirring till the alum is dissolved, the acetate of lead in powder is added. The mixture is to be carefully stirred for some time, and when the liquor begins to clarify, the potash is put in, then the chalk, in small portions at a time, to avoid too great an effervescence. The whole must now be stirred for an hour, and left to settle. The clear liquor is used as occasion requires.

For strong reds (full reds) the above mordant is thickened with starch. This is called *first red.*

If reds of a weaker tone be wanted, the mordant is thickened with gum.

For the *second red*, three pints of the mordant are thickened with two pounds and a half of gum dissolved in a pint of cold water. The whole is well mixed by due agitation.

For the *third red*, two litres (a pot) of mordant are mixed with the solution of five pounds of gum, dissolved in three pots of cold water.

The above red mordant serves also for weld fustic and quercitron yellows, with all their shades.

Mordant for Blacks.

12 pints of iron liquor (pyrolignate of iron).
4 ounces of copperas.

Dissolve the copperas in the liquor; and after having decanted the clear, mix in gradually four pounds of starch. Heat in a boiler, stirring continually, and take it out when the starch is well boiled.

Another Black Mordant.

For eight pounds of iron liquor, take about two pounds and a half of superfine wheat flour, which is to be gradually mixed up with a portion of the liquor; then add the remainder of this, and leave at rest for 12 or 24 hours, or even longer. Then boil for half an hour, or till the mixture has acquired the consistence of a paste. The boiler is then to be removed from the fire, and the mordant is to be stirred till it becomes cold. It is now to be passed through a sieve, and used in printing.

These mordants give a beautiful black with logwood, and especially madder.

Under the article Chemical Black (topical black), in Rees' Cyclopedia, (article COLOUR), we have the following recipes.

To a decoction of Aleppo galls, in five times their weight of water, made into a paste with flour, add a

solution of iron in nitrous acid, of specific gravity 1.25, in the proportion of one measure of nitrate of iron to 18 or 20 of the decoction, and a black will be formed fit for almost all the purposes of calico printing, and possessing the chief requisites of this colour, namely, tolerable fixity, and a disposition to work well with the block.

When a nitric solution of iron is added to a decoction of galls, the solution is decomposed, the oxide of iron unites with the gallic acid and tanning principle, while the nitrous acid is disengaged. This appears from the blackness which the solutions assume immediately on being mixed. The disengaged acid, however, reacts in a short time on the new compound, the blackness gradually disappears, and if the nitrate of iron has been added in proper quantity, the paste in a few days becomes, from black, of a dirty olive-green. When the proportion of nitrate of iron is greater than $\frac{1}{18}$, this change takes place sooner; and if it amounts to $\frac{1}{10}$, the paste, when applied to the cloth, will be a bright orange, like the acetate of iron. By exposure to heat and air this colour generally deepens, becoming grey, and at last a full black. In this state it is permanent, and adheres powerfully to the cloth.

These changes of colour depend on the solution of the tannate and gallate of iron in the disengaged nitrous acid, and the dissipation of the acid from the cloth, when it is exposed to heat and air. This solution of the tannate and gallate of iron is indeed an essential requisite to the goodness of the chemical black. If the disengaged acid is not sufficient to effect this, or if it is in a state of too great dilution, the colour has but a feeble adherence to the cloth. It is not presented in a state favourable to its union with it, since the combination into which the iron has entered is insoluble in water. It lies merely on the surface, but does not penetrate its fibres, and gives way readily in the various operations to which it is sub-

jected. This chemical black, therefore, is a solution of the tannate and gallate of iron in nitric acid.

Mordants for Violets (from VITALIS).

First violet.—16 pints of iron liquor;
8 pints of water;
4 ounces of Roman vitriol (sulphate of copper).

This mixture is to be thickened with powdered gum, in the proportion of a pound to the pint.

Second violet.—Mix three parts of the preceding with one of water, and thicken as above.

Third violet.—Dilute two parts of the first mordant with three of water.

Coffee Colour.

10 pints of iron liquor;
2 pints of the mordant of the *first red;*
4 pints of water.
Thicken with starch.

Puce, or Carmelite Colour.

3 pints of mordant of the *first red;*
½ pint of iron liquor.

Deep Brown.

2 pints of red mordant;
½ pint of iron liquor.

Marroon Colour (Chestnut-brown).

2 pints of violet mordant;
1 pint of red mordant;
8 ounces of green copperas, to be dissolved in the mixed mordants.

Mordoré.

8 pints of violet mordant;
12 pints of red mordant.

Deep Lilac.

1 pint of violet mordant;
1 pint of mordant for the second red.

Light Lilac.

1 pint of violet mordant;
3 pints of mordant of the second red.

Musk Colour.

1 pint of red mordant;
3 pints of black mordant.

Incarnate (Flesh) Colour; Colour between Cherry and Rose.

10 pints of red mordant;
1 pint of black mordant.

Olive Colour.

Welding on the mordant of the first, second, or third violet.

Réséda Colour.

Welding on puce mordant.

Colours of Application (Topical Colours) from *Vitalis.*

Topical or Pencil Blue.

Boil in 60 pints of water, for half an hour, 15 pounds of potash, and six pounds of quicklime, in order to render the potash caustic. Then add six pounds of orpiment (sulphuret of arsenic) reduced to fine powder, and continue the boiling for a quarter of an hour, taking care to stir continually with a rod. When the boiler is a little cooled, pour into it from six to eight pounds of indigo well ground at the mill, and stir again till the indigo be well dissolved, which is discovered by a drop of the liquor, when placed on a bit of glass, appearing yellow. The bath, while still hot, is to be thickened with a pound of gum for every pot (two litres) of liquor, or with eight ounces of starch.

This operation must be carefully preserved from contact of air, and only employed when its colour is yellow, or at least yellowish-green. If it become blue, the liquor is to be treated anew with some pounds of caustic potash and orpiment.

This blue of application, says M. Vitalis, much used formerly, is seldom employed at the present day. Another blue, of less permanence, but more brilliant, is now preferred. It is made with prussian blue, in the following manner:—

Into an earthen pot, four ounces of finely ground and sifted prussian blue are to be put. Over this must be slowly poured, stirring all the while, sufficient muriatic acid, to bring it to the consistence of syrup. The mixture is to be stirred every hour for a day, and afterwards thickened with from four to eight pots (of two litres each) of gum water, according to the shade wanted.

Topical Red.

A pound of brazil wood is to be boiled in four litres of water for two hours; the decoction is then to be decanted, and boiled down to two litres. As much red mordant must now be added as is necessary to form a fine red; and it is to be finally thickened with eight ounces of starch. The colour will be more beautiful the older the decoction of brazil wood is.

Instead of brazil wood, wood of Japan, Saint Martha, or Nicaragua (peach wood), may be used, provided their colour has been refined from the dun which they contain, by the process with milk, previously described under note MM.

Topical Yellow.

This is prepared by boiling four pounds of Turkey or Avignon berries in twenty-four litres of water, which is boiled down to one-half. The clear liquor is drawn off, and a pound and a half of alum is dissolved in it. For the light yellows, it is thickened with gum; for the deep, with starch. This topical yellow does not resist soap. The following is equally fast and agreeable.

In eight pints of water, boil four pounds of quercitron bark in powder, down to one-half of the bulk. Pass through the searce, thicken with three pounds of gum, and mix in gradually, sufficiency of solution of tin to render the colour of a brilliant yellow. This yellow resists vegetable acids and soap very well. When placed on a blue ground, it forms a fine green; and it may be applied by the plate or the pencil.

The best solution of tin which can be employed for this topical yellow, is that made with a mixture of three ounces of muriatic acid, four ounces of nitric, and four

ounces of pure water. Two ounces of grain tin are to be dissolved bit by bit in this liquor. When the solution is completed, half an ounce of sugar of lead is to be added. The mixture must then be well stirred; left to settle, and decanted. Half an ounce of the clear solution is to be taken for every pint of the yellow bath.

On mixing with the yellow bath a little of the annotto bath, we have orange yellows.

Rust-Yellow.

This is made with acetate of iron, or the *black cask.* It is thickened with gum for the light yellows, and with starch for the deeper shades. Rust-yellow, when applied on blue, gives a deep green, which serves for the stems of certain flowers.

Topical Green.

This preparation is formed by a mixture of topical blue and yellow, in which the yellow predominates considerably. The mixture must be made by little and little with the utmost care, so as to hit the wished-for shade.

Topical Aurora.

A sufficient quantity of alum in solution must be added to the annotto bath; and the mixture is to be thickened with gum.

Topical Black.

To twelve pints of the black cask, or of pyrolignate of iron, at 4° Baumé (for salts), add four ounces of Roman vitriol dissolved in water, and a sufficient quantity of decoction of galls to form a good black. Thicken with

three and a half pounds of starch, which is to be gradually worked up with a portion of the liquor. Boil, withdraw from the fire, and keep stirring, till the liquor be cool; it must then be passed through a searce or a linen cloth.

Another Topical Black.

In twenty-four pints of water, boil two pounds of logwood, two pounds of sumach, and eight ounces of galls, till the liquor be reduced to half its volume. Add then a pint of the black cask (or pyrolignate of iron); boil away six pints; take off the clear of the bath, dissolve in it two ounces of Roman vitriol, and one ounce of sal-ammoniac; after which thicken with starch, and pass through a searce before making use of the composition.

Topical Violet and Lilac.

In thirty pints of water boil six pounds of logwood, ground or in chips, till ten pints be evaporated;* decant the clear, and dissolve in it one ounce of alum for every pint of liquor. The deep violets are thickened with starch, and the light violets with gum, which is to be dissolved in the cold.

This colour changes readily; for which reason it should be prepared only as wanted, and be immediately put to use.

* Jusqu'à réduction de dix pintes.

EXAMPLES FROM *VITALIS* OF THE MODE OF MANAGING DIFFERENT STYLES OF CALICO PRINTING.

Calicoes of one Block (Indiennes à une main).

First Example. Violet on a white ground.

1. Impression of violet mordant; 2. Dunging and washing; 3. Maddering; 4. Branning and exposure on the grass for a few days, to clear the grounds.

Second Example. Black on a yellow ground.

1. Bath of yellow mordant; 2. Welding; 3. Topical black.

Calicoes of two Blocks.

First Example. First olive and second olive on a white ground.

1. Impression of the first olive mordant; 2. Impression of the second olive mordant; 3. Welding.

Second Example. Red and blue on a white ground.

1. Impression of the red mordant; 2. Maddering; 3. Impression by the block *(rentreur* †*)* of topical blue.

† When the calico is to have several colours, says M. Vitalis, for example, black, several reds, several violets, &c. as many mordants must be given as there are different colours, which must be inserted *(rentrés)* into the first plate *(figure)*, called the plate of impression (printing block, *planche d'impression.*)

The insertion *(rentrage)* of the mordants is executed by means of blocks *(planches)*, which take the name of *rentreures.* These blocks are engraved with the same patterns as the printing blocks, but so as that they apply the new mordants only to the places of the pattern reserved in the first blocks. It may be readily conceived how necessary it is for these blocks to have an exact correspondence with one another, otherwise the colours would not be comprised within the limits of their outlines. This fault is too often met with in common prints, on account of the rapidity with which they are

Third Example. Yellow and black on a white ground.

1. Impression of the yellow mordant, welding; 2. Impression of topical black.

Calicoes of three Blocks.

Example. First olive, second olive, and yellow on a white ground.

1. Impression of the first olive mordant; 2. Impression of the second olive mordant; 3. Impression of the yellow mordant; 4. Welding.

The third block *(main)* might also be performed by the impression of the topical yellow.

Calicoes of four Blocks.

Example. Black, red, violet, and yellow on white.

1. Impression of the black mordant; 2. Impression of the red mordant; 3. Maddering; 4. Impression of topical yellow, or of the yellow mordant, and welding.

Calicoes of five Blocks.

Example.—Black, red, violet, yellow, and blue.

1. Impression of the black mordant; 2. Impression of the red mordant; 3. Impression of the violet mordant; 4. Maddering, insertion of the blue, and afterwards of the yellow.

worked off, and the little care taken in their fabrication. In order that every colour may occupy the place assigned to it in the drawn pattern *(le dessein enluminé)*, adjusting brass points *(picots de rapports)* are made use of, which guide the printing on of the successive mordants, at precisely that place of the figure where the colour to be produced from each mordant ought to fall.

Calicoes of six Blocks.

Example.—First olive, second olive, black, first red, second red, and yellow on white ground.

1. Impression of the black mordant; 2. Impression of the first red mordant; 3. Impression of the second red mordant; 4. Maddering; 5. Impression of the second olive mordant; 6. Impression of the yellow mordant; 7. Welding.

It is now very seldom, however, that the number of three blocks (courses) is exceeded, on account of the high price to which the labour would necessarily raise the calico.

The following is an example of printing in fugitive colours:

Violet, black, red, and yellow, on white ground.

These four topical colours are successively applied, in the order above mentioned.

Calicoes with fast colours, after receiving the impressions, are dried, and washed from the mordants, when they are ready for the maddering.

Of Printing by Reserve, *(with Reserve or Defending Pastes).*

Goods printed by reserve, are so called, because the colour does not strike the whole surface, but only certain unprotected portions of it.

The reserve is composed of the reserve bath, and the thickening.

Reserve Bath.

Dissolve in a pint of water six ounces of sulphate of copper, three ounces of verdigris, two ounces of alum, and four ounces of gum arabic.

Another Reserve Bath.

Dissolve in two litres of water four ounces of Roman vitriol (sulphate of copper), and six ounces of verdigris, to which add one pound of gum arabic ; and when it is dissolved, pass through a fine sieve, or let it settle, and decant.

Thickening.

To thicken the bath, knead a pound of pipe-clay, well ground and sifted, with three or four ounces of water : with this thick dough carefully mix the reserve bath, and triturate well before making use of it.

The reserve is printed on the goods like the mordants. Twenty-four hours after the impression the goods are to be passed through the dyeing vat. This style is much used in blue dipping.

The theory of the reserve is very simple. The oxide of copper, which forms the basis of the reserve, restores to the indigo the oxygen which it had been deprived of by the sulphate of iron. The reoxygenated indigo loses its solubility, and consequently cannot fix on the stuff.

Since the reserve, intended to nullify the action of the indigo, essentially acts merely by the oxide of copper which it contains, it follows, that the proportions of this oxide are not indifferent, and that the measure will not perfectly accomplish its end, unless the dose of oxide of copper, which the sulphate, &c. can furnish, be adequate to neutralize the action of the indigo. A similar result would ensue, if the reserve be not suitably thickened.

Some object to the introduction of alum.

The proportions of the cupreous salts ought, however, to be as little as can effect the purpose; if their quantity

be too great, their operation would be extended to the indigo diffused through the bath.

Sometimes the sulphate of copper is made to predominate, and sometimes the acetate.

The following recipes for reserves are given by M. Vitalis:

1.	Sulphate of copper, - -	20 pounds
	Acetate of copper, - -	12
	Gum, - - -	16
	Alum, - - -	5
	Water, - - -	32 litres
2.	Sulphate of copper, - -	16 pounds
	Acetate, - - -	24
	Alum, - - -	4
	Gum, - - -	15 lb. 8 oz.
	Water, - - -	8 litres

The thickening is always made with pipe-clay.

To make a Sky-blue on a Dark Blue.

1. Dye the cloth of a sky-blue; 2. Apply the usual reserve; 3. Pass the cloth through a strong blue vat. Brighten in a bath, feebly acidulated with oil of vitriol, (or muriatic acid), to carry off the particles of lime suspended in the vat. Wash and dry.

Sky-blue, Dark Blue, and White.

1. Apply the reserve; 2. Dye sky-blue; 3. Apply the reserve anew; 4. Pass through a blue vat of sufficient strength.

Deep Blue, Sky-blue, Green, Yellow, and White.

1. Print on the reserve; 2. Pass through a weak vat, giving two or three dips; dry, brighten with very dilute

sulphuric acid, wash, dry again; 3. Print on once more the common reserve paste; 4. Dye in a stronger vat than the above, till the blue be sufficiently deep; dry, brighten as before, wash and dry; 5. Print on the red mordant, and dry; 6. Give the weld or quercitron. The mordant applied to the white spots, and to the pale blue *(petit blanc)*, affords yellow and green. The white portions that have not been touched with the mordant remain white, in like manner as the pale blue spaces, not covered by this mordant, furnish the pale blue.

Reserves are also applied to silks.

For example, on the handkerchiefs called *foulards*, the reserve is styled *waxing*.

A mixture of tallow and rosin is melted, and applied to the silk with the block; this reserve being given, the silk is dipped in the blue vat. The reserved portions being defended from the action of the indigo, remain white, while the rest of the surface takes a fast blue.

Sky-blue, Red, and White.

1. Apply the usual reserve; 2. Apply the red mordant, thickened with pipe-clay, and dry; pass through a weak blue vat, to obtain sky-blue; wash at the river, madder, wash, and spread out on the grass to clear the white.

Printing with Discharges (par rongeant) *on a Mordant.*

This process serves to form mourning garments, composed of a white figure on a black ground.

The piece of goods is first passed through the black mordant, (by means of the padding or blotching machine). When this mordant is very dry, (by passing, for example, over steam cylinders), the white discharge is applied, prepared with nitric, oxalic, tartaric, or citric acid, or bisulphate of potash, thickened with roasted starch, (British

gum). It is dried, washed, and maddered. On quitting the madder bath, the goods must be well washed, and exposed on the grass till the whites be very clear.

The portions of the cloth where the mordant has not been acted on by the discharge, will take a black of a greater or less depth from the madder, while on those places where the discharge has been applied, the mordant will be removed, and the madder colour will not combine with the stuff. Exposure on the grass will carry off the loose madder.

In like manner, by this process, white figures may readily be obtained on a ground of red, carmelite, violet, puce, &c.; since it will be necessary merely to pass through the mordant of one of these colours, then to apply the white discharge, and finally to madder.

To have white figures on an olive ground, weld or quercitron must be used instead of madder.

Printing with a Discharge on Colour, (Dyed Goods).

Suppose that the calico has been dyed in a logwood bath, mixed with iron liquor, the cloth will take a black colour. If, after dyeing, it be impressed with a solution of tin, properly thickened, the ferruginous portions of the cloth touched with the discharge will be removed, and they will pass from a deep black to a very brilliant crimson.

By subjecting to the same treatment calicoes dyed of different colours and shades, determined by the different degrees of oxidizement of the iron, a multitude of varieties will be produced, either in the colours or in their shades.

By a similar operation, we may make figures of a beautiful green on goods, by dyeing them first of a pale blue in the indigo vat, passing them then through a bath

of sumach and sulphate of iron, and finishing in a bath of quercitron with alum.

Here the green colour produced by the indigo and the quercitron remains masked, as well as the other colours, by the oxide of iron in the sulphate, till the solution of tin be applied, which causes the other colours to disappear, and gives to those that remain a lustre which they would not otherwise have had; because the solution of tin renders the quercitron yellow more vivid, and because from this vivid yellow, associated with the blue, results a more brilliant green.

A figure of aurora colour on an olive ground may be made, by passing the cloth first through a bath of sumach and sulphate of iron, then washing in an alkaline decoction of fustet, and printing on at last the solution of tin.

Let us give for an example the mode of making yellow figures on olive. The problem is reduced to find a discharge, which, in destroying the colour communicated by iron, can at the same time change the colour to yellow. This discharge is the thickened solution of tin. To the solution of salt of tin (muriate) a little muriatic acid is added. This is thickened with starch previously boiled, in a *very thick and cold state*, observing to pour in the solution in small portions, in order to ensure the thorough union of the ingredients. As soon as the piece has been impressed with this discharge, it is carried to the river to be washed, and to prevent the discharge from acting too long on the colour. If the pattern required black, it would be necessary to apply it before the yellow discharge.

Calico Printing by the combined Methods of Discharges on the Mordant and on the Dye.

First Example.—Olive, yellow, and white.

1. Pass through the olive mordant. 2. Print on the white discharge; wash and dry. 3. Weld. 4. Print on the yellow discharge.

Second Example.—Bright red, and dull red; white, yellow, and black, on an olive ground.

1. Print on the red mordant. 2. Madder. 3. Pass through the olive mordant. 4. Print on the white discharge. 5. Weld. 6. Print on the yellow discharge and the topical black, and wash.

The colours by discharges, though bright, are not so fast as those given by the dye-baths.

If, instead of applying the yellow discharge, thickened as usual with starch, one-third more starch be employed, and a colouring of decoction of Turkey berries, or brazil wood, be added, we shall obtain, in the first case, a richer yellow, and, in the second, an orange-yellow.

Of Lapis (Lazuli).

This name is given to calicoes, which, after having been printed with reserve discharges, and different mordants, are passed in succession, first through the blue vat, and then through a madder bath. If a yellow or a green be wanted, there is given, in the sequel of the madder washing, a yellow mordant, and the goods are turned through a bath of weld or quercitron.

Suppose that we are to print on cloth a pattern into which there enter white, red, black, blue, green, and yellow. The goods being previously thoroughly whitened, we proceed as follows:—

1. Apply the reserve discharge.* 2. Print on the red mordant, thickened with pipe-clay. 3. Print on the black mordant, thickened in the same manner. 4. Pass the goods through a strong vat in 48 hours at farthest after the printing has been given. The dipping ought to be for six minutes at most at two times: between each dip, the goods must be aired for five minutes. They are then carried to the river, allowed to steep in it for an hour, and washed. 5. They are dunged. 6. Passed through bran. 7. Maddered. 8. Beetled very carefully, and dried. 9. The red mordant is applied, which serves also as a yellow mordant. The pieces are now to be well cleaned. 10. They are passed through the quercitron bath, after which they are washed and finally dried.

The *lapis* pattern may be put on a blue ground, a red, green, puce, &c.; whence result a great many varieties. The pattern was originally called *lapis*, from its resemblance to *lapis lazuli*. A slight reflection on the above process will shew us how the different colours are produced.

The blue is the immediate effect of the blue vat; the red and black are developed by the maddering on the respective mordants of these colours. The combination of blue with yellow on the yellow mordant gives green. The yellow results from the colouring matter of the quercitron bark fixed by the red mordant, which is, at the same time, the mordant for yellow. Finally, the white is occasioned by the white discharge of the reserve discharge.

* The reserve discharge is prepared by melting together hog's-lard and rosin *(arcanson)*, and when the mixture is cool, diluting it with oil of turpentine; adding afterwards binarseniate of potash, and a little corrosive sublimate in powder. The whole being well blended or ground together, is to be then printed on.

A neat and expeditious style of discharge work on indigo grounds, has, of late years, been extensively employed by the calico printers in this country. A paste is made with aquafortis and pipe-clay, which is applied in the press, by a revolving cylinder of wood, having the pattern cut upon it. The cloth, immediately after receiving the impression, is passed through a strong body of steam, at 212° Fahr. issuing from a row of small orifices in a horizontal box. The high temperature gives blanching energy to the nitric acid, and the accompanying moisture dilutes it, so as to prevent corrosion of the cotton fibres. The safety of the goods, however, is ensured by a thorough washing.

BAUMÉ'S HYDROMETER FOR SPIRITS.

Temperature 55° Fahrenheit, or 10° Reaumur.

Deg.	Sp. Gr.	Deg.	Sp. Gr.	Deg.	Sp. Gr.	Deg.	Sp. Gr.	Deg.	Sp. Gr.
10 =	1.000	17 =	.949	23 =	.909	29 =	.874	35 =	.842
11	.990	18	.942	24	.903	30	.868	36	.837
12	.985	19	.935	25	.897	31	.862	37	.832
13	.977	20	.928	26	.892	32	.857	38	.827
14	.970	21	.922	27	.886	33	.852	39	.822
15	.963	22	.915	28	.880	34	.847	40	.817
16	.955								

BAUMÉ'S HYDROMETER FOR SALTS.

Temperature 55° Fahrenheit, or 10° Reaumur.

Deg.	Sp. Gr.	Deg.	Sp. Gr.	Deg.	Sp. Gr.	Deg.	Sp. Gr.	Deg.	Sp. Gr.
0 =	1.000	15 =	1.114	30 =	1.261	45 =	1.455	60 =	1.717
3	1.020	18	1.140	33	1.295	48	1.500	63	1.779
6	1.040	21	1.170	36	1.333	51	1.547	66	1.848
9	1.064	24	1.200	39	1.373	54	1.594	69	1.920
12	1.089	27	1.230	42	1.414	57	1.659	72	2.000

New French Weights and Measures (calculated by Dr Duncan, Jun.)

1.—*Measures of Length; the Metre being at 32°, and the Foot at 62°.*

		English inches.		Mil.	Fur.	Yds.	Feet.	In.
Millimetre	=	.03937						
Centimetre	=	.39371						
Decimetre	=	3.93710						
Metre †	=	39.37100						
Decametre	=	393.71000	=	0	0	10	2	9.7
Hecatometre	=	3937.10000	=	0	0	109	1	1
Kilometre	=	39371.00000	=	0	4	213	1	10.2
Myriometre	=	393710.00000	=	6	1	156	0	6

2.—*Measures of Capacity.*

		Cubic inches.		Tons.	Hhds.	Wine G.	Pints.
				English.			
Millilitre	=	.06103					
Centilitre	=	.61028					
Decilitre	=	6.10280					
Litre	=	61.02800	=	0	0	0.	2.1133
Decalitre	=	610.28000	=	0	0	2.	5.1352
Hecatolitre	=	6102.80000	=	0	0	26.419	
Kilolitre	=	61028.00000	=	1	0	12.19	
Myriolitre	=	610280.00000	=	10	1	58.9	

3.—*Measures of Weight.*

		English Grains.		Poun.	Oun.	Dram.
				Avoirdupois.		
Milligramme	=	.0154				
Centigramme	=	.1544				
Decigramme	=	1.5444				
Gramme	=	15.4440				
Decagramme	=	154.4402	=	0	0	5.65
Hecatogramme	=	1544.4023	=	0	3	8.5
Kilogramme	=	15444.0234	=	2	3	3
Myriogramme	=	154440.2344	=	22	1	2

Correspondence of English Weights and Measures with those used in France before the Revolution.

§ 1.—*Weights.*

The Paris pound, *poids de marc* of Charlemagne, contains 9216 Paris grains; it is divided into 16 ounces, each ounce into 8 gros, and each gros into 72 grains. It is equal to 7561 English troy grains.

† Recently determined by Captain Kater to be 39.37079 inches. (Phil. Trans. 1818, p. 109.)

The English troy pound of 12 ounces contains 5760 English troy grains, and is equal to 7021 Paris grains.

The English avoirdupois pound of 16 ounces contains 7000 English troy grains, and is equal to 8532.5 Paris grains.

To reduce Paris grains to English troy grains, divide by English troy grains to Paris grains, multiply by	1.2189.
To reduce Paris ounces to English troy, divide by English troy ounces to Paris, multiply by	1.015734.

§ 2.—*Long and Cubical Measures.*

To reduce Paris running feet, or inches, into English, multiply by English running feet, or inches, into Paris, divide by	1.065977.
To reduce Paris cubic feet, or inches, to English, multiply by English cubic feet, or inches, to Paris, divide by	1.211278

THE END.

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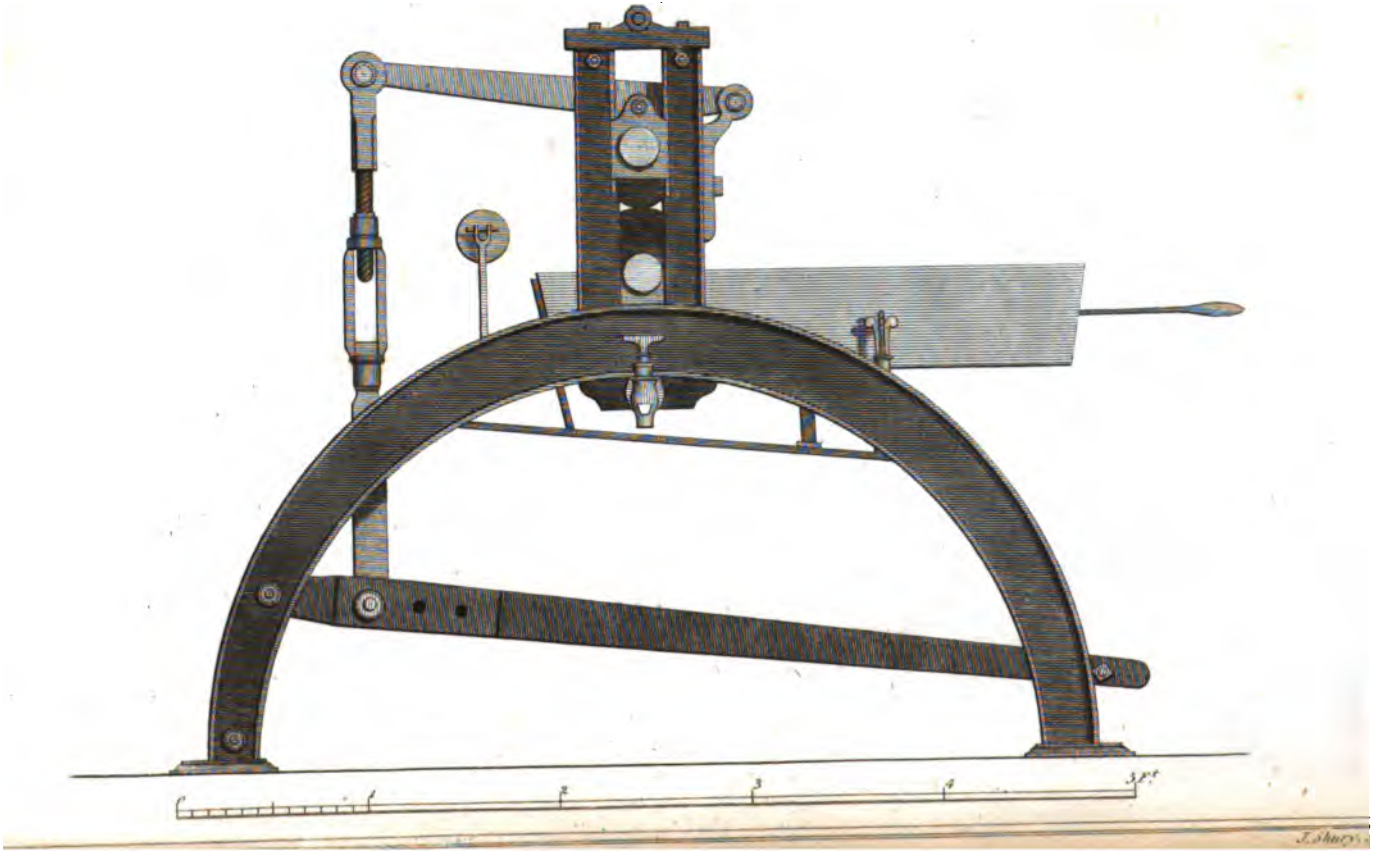
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1
2
3
4
5 Ft.
J. Shury

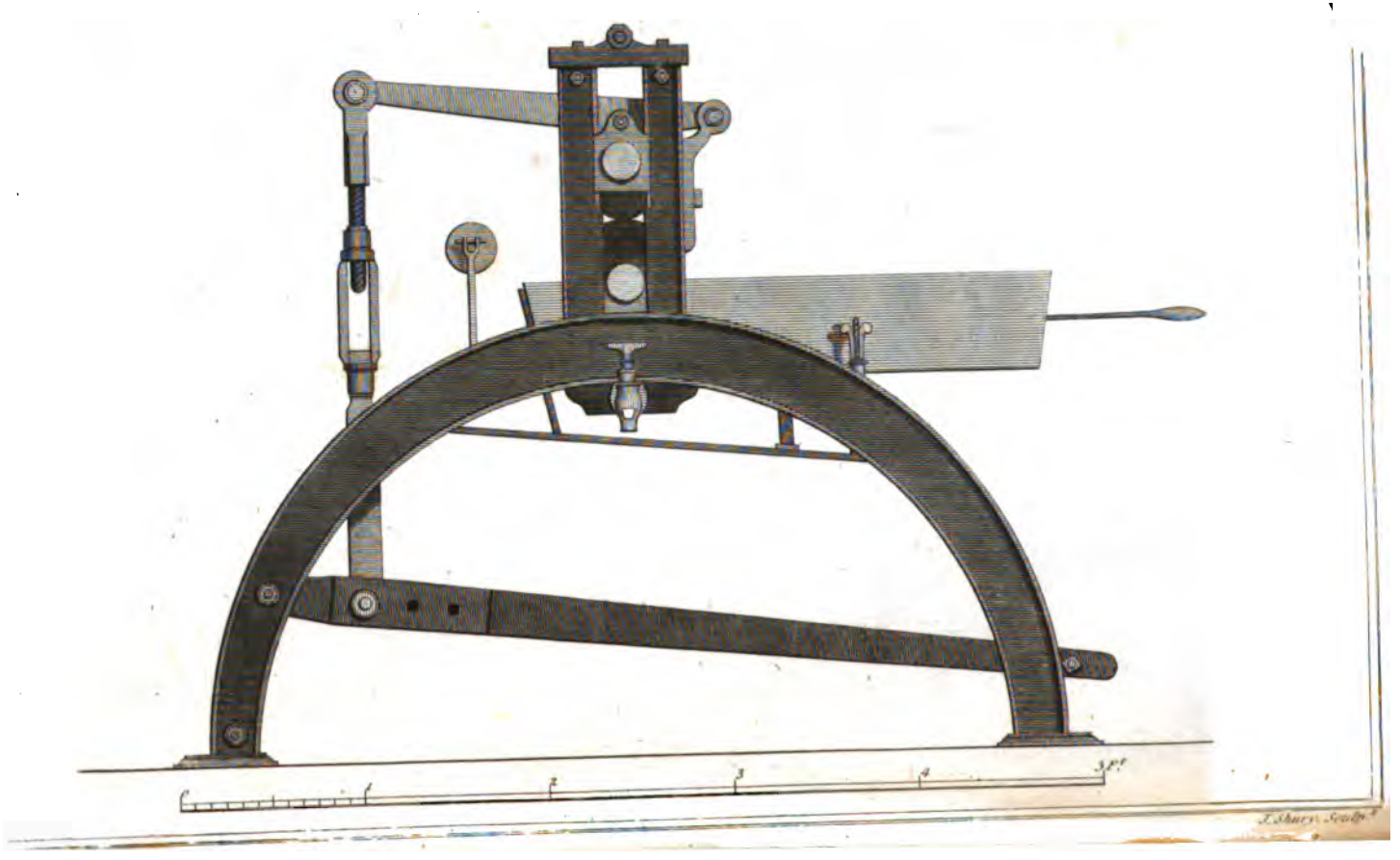
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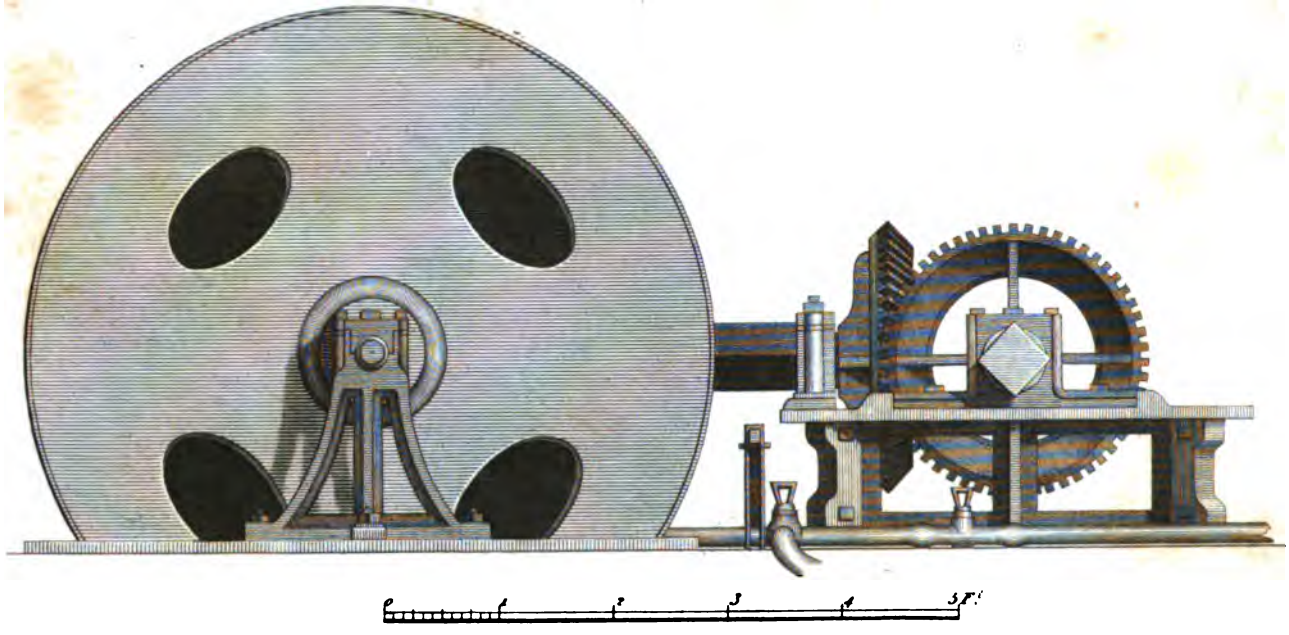
PLATE. III.



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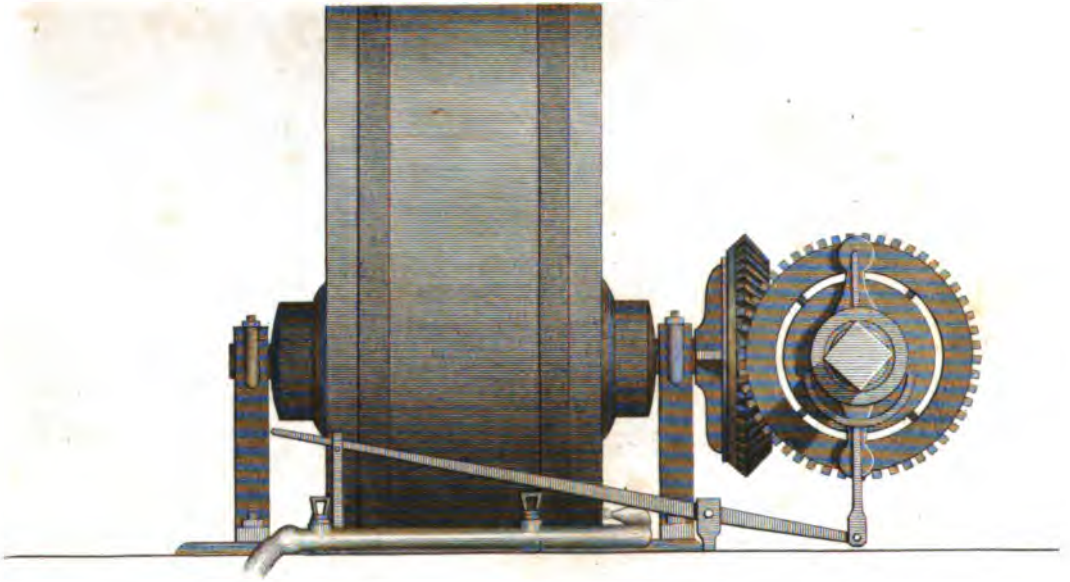

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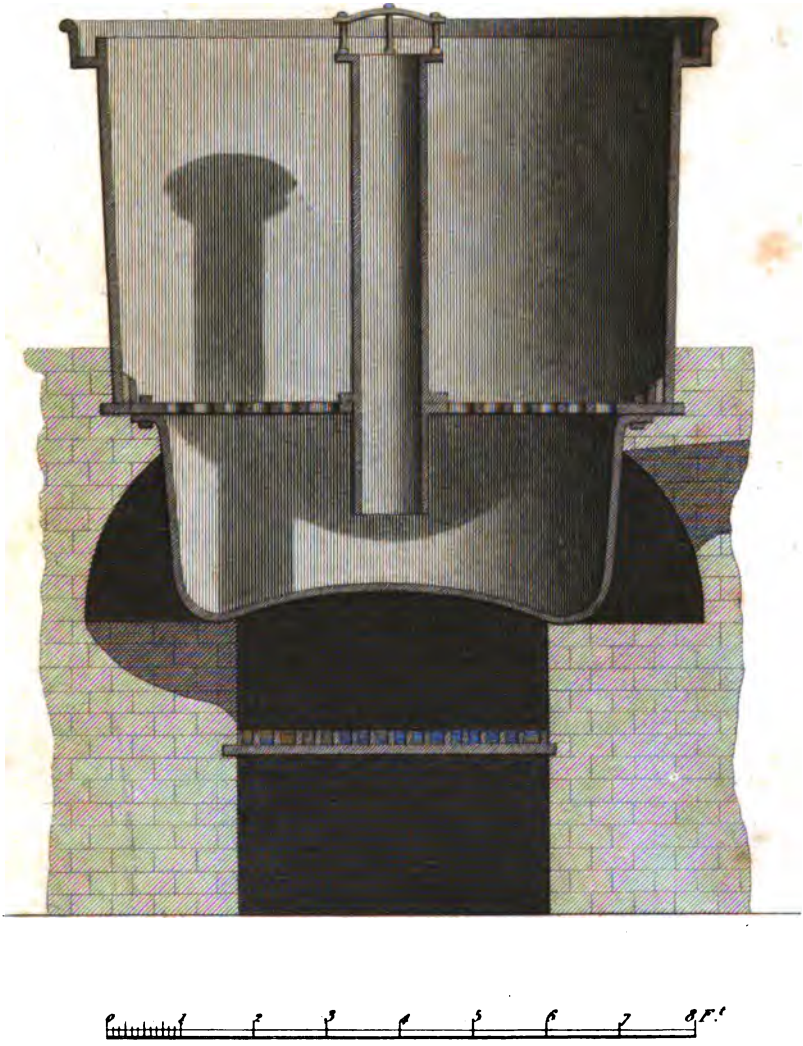

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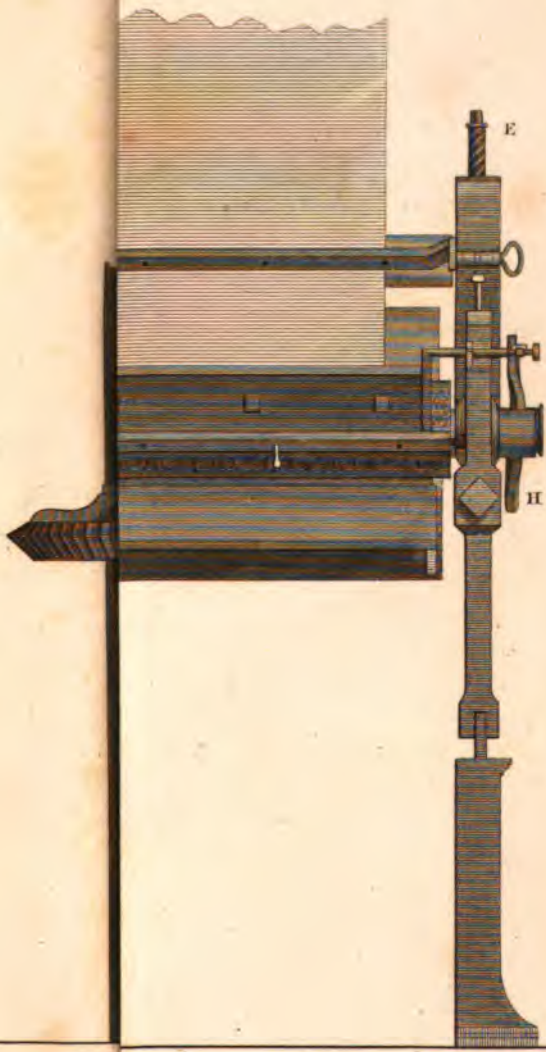

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